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Royal

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ROYAL ASTRONOMICAL SOCIETY,

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PAPERS,

ABSTRACTS OF PAPERS,

AND

REPORTS OF THE PROCEEDINGS

OF

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which will aptly form one large chapter; secondly, those which relate to another part of the phenomena, and which will form a second chapter; and so on. I trust to be able hereafter to lay before the Society a comparative account of the observations, framed, probably, on these general principles. Omitting, then, for the present, the details of observations of the mass of observers, I will first give a short account of the expedition generally, and will then subjoin a few words only on my own observations.

Having had the honour of an interview with the Duke of Somerset, First Lord of the Admiralty, on 1859, Nov. 15, I took occasion to call His Grace's attention to the approaching total eclipse, and to submit to his consideration the advantage of appropriating to the use of astronomers a ship, for their conveyance to and from the coast of Spain. Although no answer could then be given to this proposal, the reception of it was so far favourable that I was induced to speak of it, in communications to this Society, as an arrangement which might be expected. Finally, the noble screw-steamship Himalaya, commanded by Captain Seccombe, R.N., was appointed for this service.

In the meantime the Society had received several communications, of a most friendly and very important character, from Charles Vignoles, Esq., whose position as Engineer-in-Chief of the Tudela and Bilbao Railway (the whole of which was to be covered by the shadow of the totality) not only gave him a thorough knowledge of the country, its points favourable for observation, its climate, and its social resources, but also enabled him to employ his own official powers and to use his good offices with the Directors of the Railway, particularly with their Managing Director, Señor Cipriano de Montesino, for giving to astronomers the assistance of the staff of able engineers stationed at different points of the railway. Offers of assistance, of a similar kind, were made by Philip E. Sewell, Esq., Engineer-in-Chief of the Isabella Segunda Railway, extending southward from Santander, to Alar del Rey. These invitations, in addition to other considerations, sufficed to define the course of the expedition. It was arranged that the Himalaya should first touch at the roads of Bilbao, landing there a portion of the party (in which I was myself included) who relied principally on the kindness of Mr. Vignoles for guidance in the selection of stations, and for aids to reach them; and that she should then proceed to Santander to land the remainder of the party, who would receive much assistance from Mr. Sewell. The ship would then lie in the harbour of Santander, and after the completion of the observations she would receive the Santander party, again touch at Bilbao to receive the Bilbao party, and finally return to England.

Mr. Vignoles, and other persons well acquainted with the climate, had strongly insisted on the danger (from the fear of cloudy skies) of remaining in the Biscayan provinces, and

urged that a large proportion, at least, of the observers should cross the Cantabrian Pyrenees into the valley of the Ebro. This arrangement implied an addition of at least two days to the time to be spent in Spain before the eclipse, and as much after the eclipse. It was also thought important to allow sufficient time for the transport of the heavy apparatus to be used by Mr. De La Rue, and for the erection of the temporary buildings in which he proposed to mount it. After consideration of these and other points, the morning of July 7 was fixed for the sailing of the Himalaya from Plymouth Sound.

At an early time I had addressed Lord John Russell, Her Majesty's Principal Secretary of State for the Foreign Department, requesting his intercession with the Spanish Government for such a degree of relaxation of the Police and Custom-house regulations as would permit astronomers to enter Spain with facility and without the charge of duty on their apparatus. In the correspondence which followed, I received letters from His Excellency Don Xavier e Isturiz, Ambassador of the Spanish Government; from Don Antonio Aguilar, Principal of the Observatory of Madrid; and from Don F. de P. Marqua, Principal of the Observatory of San Fernando, Cadiz; and in all of these I was abundantly assured of the interest taken by the Spanish Government in the enterprise, and of their determination to withdraw, for the benefit of astronomers, all the customary arrangements of ports and frontiers, which give trouble and expense to travellers.

The Himalaya sailed from Plymouth Sound, as was arranged, on the morning of July 7. The weather was fine, and the navigation generally agreeable. And nothing will ever efface, from the minds of those who had the pleasure to share in this voyage, the recollections of the kindness and courtesy of Captain Seccombe, R.N., commanding the ship; Lieutenant (now Captain) Versturm, First Lieutenant; John Thompson, Esq., Master; and the other officers of the Himalaya. The table and other accommodations provided by the Admiralty were most liberal, and every arrangement of the ship most comfortable.

In some conferences, on the deck of the Himalaya, an attempt was made to divide among the observers the different classes of observation.

The high land of Cape Machicaco was made early in the morning of July 9, and the Himalaya dropped her anchor in the roads of Bilbao a few hours later. Mr. Vignoles, accompanied by the principal officers of Customs and Police, and other departments, came out in a small steamer to receive and welcome the Bilbao party. The baggage and instruments were nominally examined in transit; the examination consisting, in reality, of lifting the lid of one open box. No passport was examined. The following is (I believe) a list of the party who landed at Bilbao:—

G. B. Airy, assisted by Wilfrid Airy.
Rev. H. A. S. Atwood.
Joseph Beck, assisted by Walter Beck.
Joseph Bonomi.
Warren De La Rue, assisted by E. Beck, Mr. Beckley, Mr. Downes, Mr. Reynolds.
Francis Galton.
Professor Grant.
Charles Gray.
Captain Jacob.
Dr. M'Taggart.
Rev. J. S. Perowne.
J. G. Perry, accompanied by Professor Pole.
Rev. C. Pritchard, assisted by V. Fasel.
Russell Scott.
Otto Struve, assisted by M. Oom and M. Winnecke.
Rev. O. Vignoles.
John Wright.

Together with four ladies, namely Mrs. Airy, Mrs. O. Vignoles, Mademoiselle Struve, and Miss H. Airy.

The Himalaya then proceeded to Santander, and, on July 10, landed the following party:—

James Buckingham, assisted by W. Wray.
H. S. Ellis.
Professor Fearnley.
Rev. H. A. Goodwin.
R. F. Heath, assisted by J. Turner.
R. J. Hobbes.
W. Lassell.
M. Lindelöf.
Professor Lindhagen.
E. J. Lowe, accompanied by Rev. W. R. Almond and Mr. S. Morley.
Dr. Möller.
J. Stanistreet.
Professor Swan.

Of the Santander party I have at present no further account to give, and of the Bilbao party only the following. A kind reception from all parties awaited the astronomers on the Spanish land. The mayors of towns and villages, and the commandants of police, called on us and placed their powers at our disposal. On the day of the eclipse, the telegraphs were reserved for astronomical communications. But I am bound especially to say that the activity and entire self-devotion of Mr. Vignoles, his extensive private hospitality, and that of the gentlemen subordinate to him in the conduct of the Tudela and Bilbao Railway, contributed in a most important degree to the comfort of a large section of the observers, and to the success of their observations. To Mr. Bartlett, also, Resident Con-

tractor for the Railway works, we are indebted for much assistance.

Mr. Vignoles without delay despatched Mr. De La Rue's heavy instruments, &c., to the station which had been selected for him at Riva Bellosa, near Miranda. As early as possible the party were assembled at the offices of the Tudela and Bilbao Railway, and there, under the instructions of Mr. Vignoles and M. Montesino, a selection of stations was made. Omitting from this time allusion to other observers, the station allotted to M. Struve, M. Oom, M. Winnecke, and my own family party, was Pobes.* This is a very small and secluded village on the river Bayas, about two miles south of the remarkable defile of Tetches, where the Bayas issues from the Cantabrian Pyrenees. It is accessible by a good road in the direction of Orduña, Espejo, and Salinas (Anaña), as also by Vitoria and Nanclares. The Bayas, in its descent towards the Ebro, at the distance of little more than two miles, enters another defile, which is bordered on the eastern side by the hill above Hereña (called, I believe, St. Lorenzo), to be further mentioned in this account. The view from Pobes is therefore bounded on all sides by mountains, with the exception of a lateral depression on the eastern side of the valley, south of the Morillas hill, through which the mountains of the lower Ebro are seen. The church of Pobes stands on a steep knoll, perhaps 80 feet above the plain, and the churchyard surrounding it commands a very beautiful prospect.

At Pobes we were all placed under the hospitable care of Christopher Bennison, Esq., Superintendent of an extensive section of the Railway. And none of us will forget the kindness and the attention to all our wants, social and scientific, which we then experienced.

I arrived at Pobes, from Orduña, on the afternoon of Saturday July 14. On the northern side of the mountains the day had been dull and foggy, but on the south side the weather was extremely fine. I found my instruments arrived, and found Messrs. Struve, Oom, and Winnecke, engaged in astronomical observations for the determination of latitude and time. Their station for this purpose was a threshing-floor close to the churchyard. But I found that they had already selected points on the hills near Pobes, on the right bank of the Bayas, as stations for the observation of the eclipse. On viewing the country I had no hesitation in fixing on the hill above Hereña, on the left bank of the Bayas, as a very desirable post for myself.

I employed a part of the evening in endeavouring to judge (by memory) of the degree of darkness in a total eclipse. For this purpose I lighted a wax-candle, such as I had used in 1842 and 1851, and placed it on the parapet of the churchyard; and

* Pobes was the scene of some military movements immediately before the battle of Vitoria.

then, correcting my eye by its light, I remarked the time when, as I thought, the darkness appeared equal to that in the totality of 1851. It was about 8^h 30^m Greenwich mean solar time. Computing from this the position of the sun, it was about $7° 7'$ below the horizon. The evening was splendidly fine.

The next day, Sunday July 15, was magnificent. I went to the hill above Hereña, and found that it entirely satisfied my wishes. The point which I selected was the extreme eastern point, the highest part of the hill. The view of mountain and valley from this point is singularly grand. In the north-west direction, from which side the darkness would approach, the vision is limited at a few miles distance by the Pyrenees; but on the south-east side, in the direction of the retiring shadow, it extends across the Royal Road (from Vitoria to Miranda) and across and along the lower Ebro, to a very great distance. The south side of the hill is a bushy slope; the north side is a low crag of puddingstone, succeeded by a narrow flat and a talus, on which are numerous fine trees of the ilex, so common in that country, many of whose tops rise above the crag; and I could reckon with certainty on sheltering my telescope from any wind.

On the evening of July 15, finger-formed clouds began to show themselves in the north sky, and very soon there burst forth a thunder-and-lightning storm of great violence, which lasted all night. On July 16 and 17, the weather appeared completely changed. The wind blew from the north and was very cold; the near mountains were clouded very low; the distant mountains were invisible; the sun was not seen. The last-mentioned circumstance was unfortunate for me. I had prepared a telescope (constructed as I had previously explained to the Society) with a system of wires engraved on glass, containing, as an essential part, a square defined by crossing lines, within which square the image of the moon was to be brought. Pressure of business had prevented me from making many trials of this apparatus at Greenwich, but I had found that the dimensions of the square were a little too large for the sun, and I trusted that they would exactly correspond to the moon. In fact, they were a very little too large, and delicate manipulation was required for maintaining the moon exactly in the centre. I had relied on the climate of Spain for permitting me to acquire the necessary practice, when the sun should be near its meridian height on the two days preceding the eclipse; but in this hope I was totally deceived.

The morning of July 18 was cloudy; but distant mountains began to show themselves, and the aspect of the sky was improving. With the three companions of my own family whom I have mentioned, with Mr. Stead, one of the staff of railway engineers, and with nine men to carry instruments, I proceeded from Pobes to Hereña and up the hill. The weather steadily

improved, till before the eclipse began it was splendidly fine; a few clouds rather low in the south being all that was left of the late murkiness. My own telescope ($3\frac{3}{4}$-inch aperture, 46 focal length, on tripod stand) was placed a few yards west of the end of the hill; the power used was about 50. The telescope used by Wilfrid Airy ($3\frac{1}{4}$-inch aperture, 36 focal length, on tripod stand) was placed about twenty yards further west; the power used was about 100. I had a duplex watch, Molyneux 1007, beating $\frac{2}{5}$ seconds; Wilfrid Airy had a lever watch, Dent, beating $\frac{1}{4}$ seconds. The rest of the party had no telescopes or trustworthy watches.

Before giving the observations themselves, I will premise some numerical elements necessary for their reduction.

In comparing the observations made at numerous stations, it is evidently desirable to refer all the stations to a common system of geographical co-ordinates; and much of the clearness of our results may depend on the due choice of the system of co-ordinates. Now it appears evident that we want, not terrestrial longitudes and latitudes, but something which will show the relation of each observation to the following two elements,—first, the absolute time of the phenomenon; secondly, the nearest distance of the sun's centre from the moon's centre as seen at the place of observation. These elements are well connected with co-ordinates, of which the abscissa is measured along the central line of shadows, and the ordinate is measured along a line of simultaneous centrality of totality. The lines of which I speak are drawn upon Mr. Vignoles' map. I have therefore taken the measures from that map, using the minute of latitude as the unit of measure. For the zero of abscissa I have taken the western border of the map. The co-ordinates of Pobes, thus defined, are nearly,—

Abscissa 152; Ordinate 19 N.E.

A solar chronometer, Molyneux 2184, was carried from Greenwich. It was usually in the custody of M. Struve, and was undoubtedly treated with all possible care. Comparisons of its indications with Greenwich mean solar time were made before going and after returning, of which the following may here suffice:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

			h	m s
1860,	June	23	0	2 5·0
	July	5	0	2 39·0
	July	30	0	4 2·4
	August	11	0	4 36·4

The mean daily rates in the three several groups are $2^s{\cdot}83$, $3^s{\cdot}34$, and $2^s{\cdot}83$. The agreement of these gives great confidence

in the uniformity of rate from July 5 to July 30. Adopting $3^s.34$, we have the following results:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

	h	m s
June 17	0	3 19·1
18	0	3 22·4
19	0	3 25·8

I am informed by M. Winnecke that the errors of the chronometer on Pobes mean solar time (as found by astronomical observation) at these epochs were $8^m\ 18^s.0$, $8^m\ 15^s.1$, $8^m\ 12^s.1$, fast. These give for the longitude of the threshing-floor near the churchyard of Pobes $11^m\ 37^s.1$, $11^m\ 37^s.5$, $11^m\ 37^s.9$. Its latitude was found to be $42^\circ\ 48'\ 5''$.

Again we have,

Molyneux 2184, slow on Greenwich Mean Solar Time:

	h	m s
June 17	22	3 22·1
18	22	3 25·5

At these times, Molyneux 1007 was faster by $2^m\ 46^s.4$ and $2^m\ 52^s.5$; and Dent was slower by $15^m\ 56^s.0$ and $17^m\ 9^s.5$. From these we find with sufficient approximation, at July 18, 2^h to 4^h,

	m s
Molyneux 1007, slow on Greenwich Mean Solar Time	0 35·1
Dent slow	19 31
to	19 37

Finally, as it was my intention to refer angles to wires in the telescope having a definite relation to the vertical, it was necessary to ascertain the angle made by the vertical with the astronomical meridian. On calculation it appears that the angles were,

	h m		° ′
At	2 50	Greenwich Mean Solar Time	46 39
	3 0	... ...	47 41
	3 10	... ...	48 35

During the $3\frac{1}{3}^m$ of totality, this angle therefore changed by about $19'$; a quantity smaller than I could answer for in my observations, but which in more delicate measures ought not to be omitted.

I shall now proceed with my observations.

For observations of time, I commenced counting the $\frac{2}{5}$ beats of my watch at some decade of seconds, and counted up to 25 ($=10^s$), after which I again began counting. Thus I observed the first contact at $1^h\ 47^m\ 30^s$ of Molyneux 1007. My eye, however, was directed (in consequence, as I have since found,

of an error in the position of my wires) to a point on the sun's limb about 5° too high; and in consequence I did not perceive the very first contact. I think that it had taken place about 4^s before the time noted. This gives for watch-time $1^h\ 47^m\ 26^s$, or for Greenwich mean solar time $1^h\ 48^m\ 1^s$; which I consider very exact.

On the progress of the eclipse I have nothing to remark, except that I thought the singular darkening of the landscape, whose character is peculiar to an eclipse, to be sadder than usual. The cause of this peculiar character I conceive to be, the diminution of light on the higher strata of air. When the sun is heavily clouded, still the upper atmosphere is brilliantly illuminated, and the diffused light which comes from it is agreeable to the eye. But when the sun is partially eclipsed, the illumination of the atmosphere for many miles round is also diminished, and the eye is oppressed by the absence of the light which usually comes from it.

I had a wax-candle lighted in a lantern, as I have had at preceding total eclipses. Correcting the appreciations of my eye by reference to this, I found that the darkness of the approaching totality was much less striking than in the eclipses of 1842 and 1851. In my anxiety to lose nothing at the telecope I did not see the approach of the dark shadow through the air; but, from what I afterwards saw of its retreat, I am sure that it must have been very awful.

At $2^h\ 59^m\ 30^s{\cdot}0$ of my watch I commenced counting the beats, holding the watch to my ear, and recommencing the counting at the end of 25 beats. When, from the narrowness of the sun's lune, I judged that the totality would occur in ten or fifteen seconds, I withdrew the graduated coloured glass. To my infinite astonishment, while the white sun was still shining brilliantly, I saw in great splendour two red prominences (possibly more than two were visible) and one double floating red cloud. I am not certain whether the red sierra was then visible, or whether it became visible after the white disk had disappeared. But, before the white disk had disappeared, the white corona formed round the moon, I think all at once; and the moon was seen complete, with dazzling sun, brilliant corona, and brilliant prominences. The intensity of light in the corona and prominences was not much increased at the total disappearance of the sun.

The co-existence of all these lights really introduced much confusion in the observation of the time of formation of totality. I found myself counting the beats of my watch up to 45, and I set down the time of totality as $2^h\ 59^m\ 30^s + 45$ beats. But I was afterwards under the impression, and now fully believe, that I had passed one counting of 25 beats; so that the register ought to have been $2^h\ 59^m\ 30^s + 70$ beats. This makes the time $2^h\ 59^m\ 58^s$ of my watch, or $3^h\ 0^m\ 33^s$ Greenwich mean solar time.

In a former communication to the Society I stated my intention to use a system of wires embodying the following conditions: 1. That there should be a square, pretty exactly containing the moon; 2. That there should be a system of 12 crossing lines, or 24 radii passing through the centre of the square, and inclined each to its neighbour at an angle of 15°; 3. That two of these crossing lines should be stronger than the rest, one approximately in the direction in which it was found (by calculation) that the moon would apparently cross the sun, the other in the direction normal to that crossing motion. And I proposed to observe the angular position of any prominences which might be near to the normal line. Mr. James Simms had furnished me with a reflecting eye-piece taking a definite position (as to angular rotation) in the telescope, and bearing such a system of lines etched on the reflecting prism; the position of the strong normal line being a few degrees in error. On bringing the moon into the square I found that there were two appearances which precisely corresponded to my wishes; one a prominence exactly 15° to the apparent left (or on the radius whose angle, measuring from the upper normal in direction of watch-hand-motion, is 345°); the other the double floating cloud, exactly 15° to the apparent right; both being bisected by the radial lines. A third large and conspicuous prominence more to the left, at perhaps 300°, I merely saw with a single glance. There might be others which I did not remark.

[I may take this opportunity of stating that the colour of these appearances was not identical with that which I saw both in 1842 and 1851. The quality of the colour was precisely the same (full blush-red, or nearly lake), but it was diluted with white, and more diluted at the root of the prominences close to the moon's limb than in the most elevated points.]

I proceeded as soon as I could with my measures (to be given below). About the middle of the totality I ceased for a while, in order to view the prospect with the naked eye. The general light appeared to me much greater than in the eclipses of 1842 and 1851 (one cloudy, the other hazy), perhaps ten times as great; I believe that I could have read a chronometer-face at the distance of 12 inches; nevertheless, it was not easy to walk where the ground was in the least uneven, and much attention to the footing was necessary. The outlines of the mountains were clear, but all distances were totally lost; they were in fact an undivided mass of black, to within a small distance of the spectator. Above these, to the height perhaps of six or eight degrees, and especially remarkable on the north side, was a brilliant yellow or orange sky, without any trace of the lovely blush which I saw in 1851. Higher still the sky was moderately dark, but not so dark as in the former eclipses. The corona gave a considerable body of light; I did not

remark, either by eye-view or by telescopic view, any thing annular in its structure; it appeared to me to resemble, with some irregularities (as I stated in 1851), the ornament round a compass card. But the thing which most struck me was the great brilliancy of *Jupiter* and *Procyon* so near to the sun. It was impossible that they could have been seen at all, except under the circumstance of total absence of illumination on that part of the atmosphere through which their light passed.

I returned to my measures, but I was soon surprised by the appearance of the scarlet sierra announcing the approach of the sun's limb. It disappointed me, for I had reckoned on a much longer time. All our party who were aware of the predicted duration fully believed that it must have been very erroneous. How the time had passed I cannot tell. The sun at length appeared, extinguishing the sierra, but the prominence and cloud remained visible, and my last measures were taken after reappearance. The prominence, &c., were then rapidly fading, and I quitted the telescope, not without the feeling that I had not done all that I had intended or hoped to do.

I looked around me, and in the southeast direction and for some time, perhaps ten seconds, I saw nothing remarkable in the atmosphere. About that time, as the light about me grew stronger, the darkness in the south-west attracted attention, and before long it looked as if the very air on that side was composed of blackness and opacity. The mountains along the Ebro were totally lost. A full half-minute passed, I think, before the darkness had so far diminished as not to produce the dominating impression of the scene.

My companions saw nine celestial objects, eight of which were identified by means of Mr. Hind's chart, and the ninth by our knowledge of its position. They appeared to be (using Mr. Hind's numbers of reference), 2 *Regulus*, 3 *Saturn*, 4 *Mercury*, 6 *Procyon*, 7 *Jupiter*, 8 *Venus*, 9 *Pollux* or 11 *Castor*, (not quite certain), 13 *Capella*, and *Arcturus*. *Sirius* and *α Orionis* were hidden by clouds.

I now proceed with my measures. I must premise that I used a reflecting eyepiece, and therefore my image was erect with regard to up and down, and inverted with regard to right and left. My angular measures, which were made in the direction of watch-hand-motion, must be interpreted as made in the opposite direction. The strong normal line which was my zero of angle, was inclined, its upper part apparently to the left or really to the right, by about $9\frac{1}{2}^\circ$, and that quantity must be subtracted from all measures in order to refer them to the upper vertical. Finally, the angle $47^\circ\ 50'$ (found above) must be added (making the entire correction $38^\circ\ 20'$ additive) in order to refer the measures to the north meridian. The following are the measures as recorded; the angles being expressed by number of wire (which is to be multiplied by 15°) and by fractions of intervals of wires (or fractions of 15°). The

number of observations, it is conceived, divide the time into nearly equal parts:—

	Prominence.	Cloud.
No. 1	Measure lost in observing the time.	
2	$23^d + \frac{1}{6}$ interval.	$1^{st} + \frac{1}{6}$ interval.
3	$23^d - \frac{1}{5}$	$1^{st} + \frac{1}{5}$
4	Measure lost in quitting the telescope.	
5	Measure lost in quitting the telescope.	
6	$23^d - \frac{1}{5}$	$1^{st} + \frac{1}{5}$
7	$23^d + 0$	1^{st} + very little.

or the angles from north meridian, measured in the direction opposite to watch-hand-motion, are,

	Prominence.	Cloud.
	° ′	° ′
No. 1	...	...
2	25 50	55 50
3	20 20	56 20
4	...	...
5	...	...
6	20 20	56 20
7	23 20	53 20+

I left the telescope with the impression that the angles here measured had decidedly and distinctly decreased; and so, on the whole, it appears from the numbers, but not incontrovertibly. I wish that I had been provided with better means for delicate motion of the telescope than the rack-and-pinions of the steadying rods.

The end of the eclipse was at $4^h\,9^m\,14^s$ by my watch, or $4^h\,9^m\,49^s$ Greenwich mean solar time, pretty good.

Perhaps the following remarks on the progress made in the observation of successive eclipses may not be without value:—

In 1842, I, with all the rest of the astronomical world, was taken by surprise with the appearance of red projections. In 1851, various important observations of the elevations of projections were made: I cite M. O. Struve's micrometical measures as the most valuable, and I should be glad if my own general observations of disappearance on one side and non-appearance on the other side were thought useful. One observer (I think not more) obtained a good measure of angular position. In succeeding observations which have been made in different parts of the earth, I think that no novelty has been introduced. In 1860 we have got not only good angular posi-

tions, but also fair attempts at measure of change of angle; and this will be seen more distinctly when the results deducible from Mr. De La Rue's photographs shall be published.

It is scarcely possible that I should observe a fourth total eclipse, and I can therefore only offer to future observers the advice upon which I should have acted myself. Whatever be the trouble and expense, and however small the chance of success in the observation, *use a good steady equatoreal, driven by good clockwork, and having easy transversal adjustments for the wire-frame.* With the system of wires that I have used (and which is described in the *Monthly Notices* for 1860, March 9, pp. 187, 188) I am well satisfied.

I extract the following notices from the accounts of my companions.

Wilfrid Airy observed the commencement of totality at $2^h\ 40^m\ 1^s$ by his watch, with the remark that, in consequence of a want of correspondence between the minute-hand and the second-hand, there might be an apparent error of 1^m. The application of the reduction computed above gives for the equivalent in Greenwich mean solar time, $2^h\ 59^m\ 35^s$; which, as compared with my observation, appears to be 1^m too small, but in other respects agrees closely.

By one of those inadvertencies which oppressed almost every observer during the excitement of the eclipse, Wilfrid Airy forgot to withdraw the coloured glass from the eye-piece, and actually observed the red prominences through it. This must be borne in mind as qualifying some of the statements that follow. "As soon as the totality commenced, the red prominences became visible, but I did not observe them before the totality. I did not notice the corona at all through the

telescope. The appearance and position of the prominences were as follows:—[the drawing, from the reversed image, being again reversed here to form a correct image.]

"Prominences 1, 2, 3 seemed to appear all at the same

moment; and 4 might have appeared also at the same time, but I did not notice it so soon. Prominence 5 did not appear till after the others, and was at first extremely hazy, but gradually thickened as the moon passed on. Prominence 4 disappeared about 1^m after the formation of totality, and I did not see it again. After the sun had burst forth, I noticed a prominence which would have been somewhere about 6; and this, as well as 1 and 2, I could see 2^m after the sun had reappeared. (I did not notice 6 before the sun reappeared, because I had left the telescope.) The colour of the prominences was a bright rose-colour, and 4 was brighter than 1, 2, and 3. Prominence 5 was lighter a good deal than the others.

"The stars that I noticed were *Jupiter*, *Mercury*, *Regulus*, *Saturn*, and *Arcturus*. *Arcturus* was bright. I saw no stars to the west of the sun."

[1 and 5 are the two objects whose positions I measured. It appears that Wilfrid Airy saw 5 as a prominence; whereas I, and also Mrs. Airy, who looked into my telescope, saw it as a floating cloud. 2 is the other prominence, which I saw in a glance.]

Wilfrid Airy saw the termination of eclipse at $3^h\ 50^m\ 4\frac{1}{2}^s$ by his watch, or $4^h\ 9^m\ 41^s$ Greenwich mean solar time, with the same caution as to possible error of 1^m.

From Mrs. Airy's notes I extract the following:—

"At last [some time after commencement] the light began to be sobered, like that of a summer evening, and soon a gloominess began gradually to creep over the whole scene, as if a storm were coming on. The southern mountains beyond the Ebro began to stand up strangely black. Then a sickly green hue began to creep over the whole nearer landscape. A peculiarly mournful sighing wind, cold and strong, began to rise as if from among the large old trees beneath us on the north side of the hill; and, looking down among them from the edge above, their dark green masses became every moment of a deeper green tinge, while the white old trunks gleamed whiter still. The butterflies disappeared, but the swifts continued on the wing. These appearances grew more and more intense, and all 'instructions' were totally forgotten in the excitement of the moment. It became very cold, and I was glad to wrap myself up in a large Scotch plaid. . . . The crescent diminished to a thread, the gloom everywhere intense. I was particularly struck with the moaning of the wind among the old forest-trees beneath me. The swifts had now disappeared. A deeper gloom filled the sky in the north-west, and came sweeping rapidly on. The moment of totality had come: the whole air was at once filled with darkness, yet it was darkness through which mountain and valley could be distinctly seen. To me it seemed as if we were in the midst of a streaky shower of smoke or fine dust, which, however, was perfectly clear, and which

could not be felt. It was only for a moment that I was struck with this appearance sweeping along the valley between us and the northern hills. The range of southern hills was of an inky black, while the sky beyond them was an intense golden orange. I have often seen a similar, though much fainter, effect in watching a fine summer sunset from the Greenwich Observatory through the smoke of London, when the air has been dry and the smoke very thin. These glorious colours were quite a new feature to me, for at the eclipse of 1842 the sky was entirely clouded. My shadow on the ground was quite black and sharp: the effect was like that of clearest moonlight. I could see the whole country, but I had to stoop in order to see my footing among the stones and shrubs. At the critical moment I forgot to remove the dark glass from my eye, and thus lost what I remember to have been the most striking phase of the whole phenomenon on the former occasion, viz. the starting out of the corona on the right side before the last thread-like crescent of the sun had disappeared on the left side of the moon. On that occasion, however (1842), it was a narrow fringe or border round the moon of soft light, of a uniform breadth, and slightly beaming texture, soon graduating into the darkness outside; while now it was a bright radiating glory of much wider extent, and its appearance made very singular from the projection of four or five brllliant beams at about equal intervals, far beyond the width of all the rest. I saw three bright stars near the sun; I could not, with the unarmed eye, see the red prominences. I looked for a few seconds in the telescope, and then I did see two of these wonderful appearances, but so faint in comparison with those of 1842 that for a moment I did not recognise them. One was a floating cloud, quite separate from and suspended over the upper edge of the moon, nearly divided into two parts by an indent below, of so pale a colour that at first it seemed almost white; but as I looked at it more steadily I perceived that it was of a pale rose-colour, the colour deepest against the upper edge, which was well defined, and becoming gradually paler to the lower indented edge. The other was lower down the edge of the left side of the moon, and not separated from it, but rising from it like those of 1842—a broad cone, cloven at the top; its colour was pale, like the other, and, like the other, it had a cloudlike and not a solid appearance."

At the reappearance of the sun, "We saw the dark shadow distinctly sweeping away along the valley to the south-east, a path of darkness, and the clear daylight breaking out behind it."

We descended from our hill-station, and on our way to Pobes we had the satisfaction of learning that M. Struve had been successful in his observations; and in no long time we were gratified by the intelligence that Mr. De La Rue's photographic operations during the totality had entirely answered to

his wishes. On July 20, I had the pleasure of visiting Mr. De La Rue at his station at Riva Bellosa; and, in admiring his observing establishment, I was much struck with the importance of his elaborate preliminary arrangements, in providing a first-class instrument, and carefully training his assistants; to which preparations his success is entirely to be attributed. On July 21, I, with my party, quitted the house of our most hospitable friend Mr. Bennison, for Vitoria, where I had the advantage of meeting Professor Mädler and M. Hermann Goldschmidt. I received here a telegraphic invitation from the Spanish Government, conveyed personally by the Secretary of the Governor of Viscaya, to join an Eclipse Congress at Madrid: the distance, however, and the pressure of home engagements, made it impossible for me to accept it. On July 22, we were again welcomed by our unwearied friend Mr. Vignoles, at Bilbao.

At our landing from the Himalaya, on July 9, it had been arranged that the ship should leave Santander for her return on the evening of July 23, and leave Bilbao on July 24. It now appeared, however, that the great festival of St. Jago, the patron saint of Spain, occurring on July 25, was to be celebrated by a bull-fight at Santander. In order to show our respect to a people from whom we had received so many marks of kindness, as well as to secure a longer time for collecting instruments, &c., the ship, at my request, was detained at Santander till the night of July 25, by which time all the Santander party had come on board. She lay the whole of July 26 in the roads of Bilbao, visited by many of the inhabitants. The Bilbao observers joined on that evening, and the vessel sailed immediately. We had left a few of our party, who proposed to return by land; their places were occupied by Mr. Vignoles, M. Montesino, Professor Chevalier, Mr. Wilson, and Professor von Weyer.

Many were the accounts of success and of misfortune to be told. It was matter of universal sorrow that the best friend of the expedition, Mr. Vignoles, had failed to see the eclipse. The Bilbao party had, for the most part, been successful; the Santander party, for the most part, were unsuccessful. Among these we were sorry to learn that our respected Fellow, Mr. Lassell, was to be numbered. After a most agreeable voyage, we anchored at Spithead about 4 P.M. on July 28, and landed in time for the railway-train which reached London on the evening of that day.

An account of the phenomena of the total eclipse as observed, under very favourable circumstances, at Burgos, was received from T. C. Janson.

Eclipse of the Sun, July 18, 1860. Observed at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Observer.	Mean Solar Time of Observation. First Contact.	Last Contact.
	h m s	h m s
M.	1 39 26·4 (*a*)	3 54 2·8 (*b*)
G.	1 39 30 (*c*)	3 53 57 (*d*)
D.	1 39 30·0 (*e*)	3 54 6·7 (*f*)
E.	1 39 34·0 (*g*)	3 54 1·0
J.C.	1 39 24·6 (*h*)	3 54 7·2 (*i*)

(*a*), (*h*), The time noted is that at which the sun's limb was first indented by a prominence in the moon. (*b*), (*f*), (*i*), Satisfactory. (*c*), Considered within a second of the truth. (*d*), Not so accurate as the observation of the first contact. (*e*), The moon's limb very mountainous at the point of contact. (*g*), Two or three seconds previously to the time noted, the sun's limb was indented by two prominences.

The initials M., G., D., E., and J. C., are those of Mr. Main, Mr. Glaisher, Mr. Dunkin, Mr. Ellis, and Mr. Carpenter.

The following accounts of the Eclipse, as observed in England, have also been received:—

Eclipse of the Sun, July 18, 1860.

Observed at Greenwich Hospital, by John Riddle, Esq.

The eclipse had commenced some seconds before it was observed at $1^h\ 39^m\ 55^s$.

The approach of the moon's limb to the spots marked in the diagram was well marked; the observations remarkably satisfactory.

Spot.		h m s
No. 2.	The first with which the limb came in contact, disappeared at	1 53 47·5
No. 3.	First contact with large spot in Group A	1 55 4
No. 4.	Extremity of large spot disappeared	1 55 37
No. 5.	Disappearance of spot	1 56 36
No. 6.	Final disappearance of penumbra	1 56 43
No. 7.	Disappeared at	2 1 43
No. 8.	,, ...	2 2 6·5
No. 9.	,, ...	2 2 25
No. 10.	Well-defined small spot	2 6 24·5
No. 11.	,, ,, ...	2 25 15·5

A faint group followed, but offered no salient points for observation with the telescope employed.

No. 12 is a large double spot with a well-defined penumbra. Observed in the following order:—

	h	m	s
1. Penumbra, 1st contact	2	36	13·5
2. 1st contact with spot	2	36	30·5
3. Middle space reached	2	36	38·5
4. Extremity of spot disappeared	2	36	56

Next came the small spot marked

	h	m	s
No. 13.	2	37	35·5

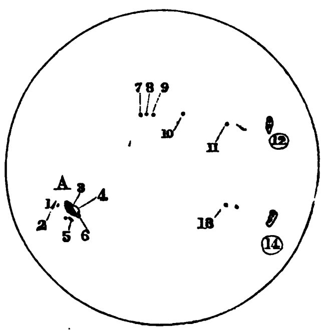
The following small spot was lost.

The larger group marked No. 14 was admirably well defined and observed as follows:—

	h	m	s
1. First contact with penumbra	2	44	40
2. First contact, upper spot	2	45	4
3. Spot disappeared ...	2	45	17·5
4. First contact, lower spot	2	45	33
5. Spot disappeared ...	2	45	45·5
6. Penumbra	2	45	52·5

The reappearances of the spots were confined to the complete reappearance of Group A at $3^h\ 0^m\ 32^s$, observed by Mr. Mugridge; and spot No. 10 at $3^h\ 16^m\ 38^s.5$.

Telescope 2 ft. 8 in.; aperture 2·6 in.; power 40.



Sketch of the Spots on the Sun during the Eclipse of the Sun, July 18, 1860.

Greenwich Hospital, July 18, 1860.

Observed at Greenwich, by Rev. Geo. Fisher, M.A. F.R.S.

1. Sextant measures and distances of cusps.
2. Breadth of illumined portion of solar disk at right angles to the line of cusps.
3. Times of commencement and end of eclipse.

Time, Chronometer. h m s	Dist. of Cusps. ′ ″	Time, Chronometer. h m s	Dist. of Cusps. ′ ″
9 46 9	23 15	10 33 17	31 35
9 47 11	23 20	10 35 20	31 25
9 48 52	25 15	10 40 52	31 10
9 50 21	26 15	10 42 8	32 0
9 55 46	26 30	10 43 10	31 15
9 57 1	26 50	10 44 12	32 10
9 58 12	26 55	10 45 10	31 10
9 59 25	27 15	10 55 47	30 15
10 4 54	29 5	10 57 11	30 10
10 6 3	29 30	10 58 25	30 20
10 7 1	28 45	10 59 27	30 30
10 9 0	29 15	11 4 40	29 20
10 14 13	30 20	11 5 52	29 5
10 15 30	30 30	11 7 11	28 15
10 17 37	30 30	11 27 37	19 30
10 22 32	30 30	11 28 55	18 35
10 24 18	31 15	11 30 0	18 20
10 26 17	31 15	11 35 20	13 20
10 27 16	32 0	11 36 41	13 30
10 30 30	31 55	11 37 26	12 45
10 31 57	31 25		

Time, Chronometer. h m s	Greatest Breadth of Illumined Portion of Disk. ′ ″	Time, Chronometer. h m s	Greatest Breadth of Illumined Portion of Disk. ′ ″
10 36 10	5 0	10 49 30	7 30
10 37 48	4 45	11 0 46	12 40
10 39 14	5 0	11 2 5	13 5
10 46 25	7 0	11 3 10	14 0
10 47 35	7 15	11 8 17	16 15

The foregoing measures were taken by myself with an 8-inch sextant at the Greenwich Hospital School Observatory. They are given as read off from the instrument, without the omission of a single observation, and require 34″ to be taken from each for index-error, which was determined with great care before and after the observations.

The times were observed with a chronometer going sidereal time, and require each to be increased by 18^s, the quantity

which the chronometer was slow of sidereal time, as determined by comparisons with the transit-clock before and after observations, both comparisons agreeing.

Although the weather was occasionally cloudy, yet the measures were taken under favourable circumstances, and accord with each other as nearly as can be expected in single sextant observations.

The commencement and end of the eclipse were also observed under favourable circumstances with a 40-inch equatoreal of 3-inch object-glass, power 45, as follows:—

	Sid. Time.	M. S. Time.
	h m s	h m s
Commencement	9 26 3	1 39 43
End	11 40 37	8 53 54

As a very slight impression upon the sun's limb was made when the time of the commencement was recorded, perhaps about 1 or at most 2 seconds of time might be subtracted from the time here given, making the mean sidereal time of commencement $1^h\ 39^m\ 41^s$, instead of $1^h\ 39^m\ 43^s$.

Latitude 51° 28′ 50″ N.; Longitude $0^s.2$ W.

Greenwich Hospital Schools, July 19, 1860.

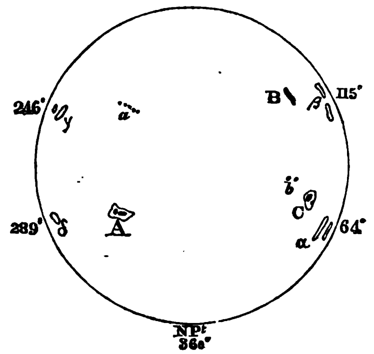
Observed at Maresfield, Sussex, by Captain Noble.

For some two hours prior to the moment of first contact I was occupied in the delineation of the map of the sun, which accompanies this paper, and which represents that luminary at a mean epoch of July 18th, 1^h G.M.T. Reference to the key to the larger drawing will show that I have lettered the three large maculæ in the order of their right ascension, A, B, and C; the minute groups I have called *a* and *b*; and the four most noticeable faculæ are designated *α*, *β*, *γ*, and *δ*. The chief spot (A) consisted of several umbræ contained in, or surrounded by, one penumbra; and it will be seen that prolongations of this penumbra extended to some, otherwise isolated, minute spots, at some little distance from the main mass. Spot B was of a long oval form, and a curious (dark) break was perceptible, dividing the umbra into two portions; and spot C consisted of two separate ones, surrounded by a single penumbra. The two small groups, *a* and *b*, scarcely demand any notice. With reference to the faculæ, that marked *α* in the key-map was situated at an angle of about 64° from the true north point, measuring (as in the ordinary position-micrometer) towards the east. It was double, and consisted of two nearly parallel fusiform streaks of light; the smaller, or following, one of which inclined at its higher, or southern part, towards the larger. *β* was a very confused group of faculæ (with maculæ intermixed) *just being* brought on to the sun's disk by his rotation; it was at

a position-angle of about 115°. Proceeding onwards, we arrive at γ, another double facula, with a distant resemblance to α. In this case the preceding streak inclined towards the other in a sharp curve; they were about 246° from the north point. Finally, δ, at an angle of 289°, reminded me forcibly of a "Prince Rupert's drop" in its form: it was quite isolated. I may add that I took great pains with the drawing and mapping of the various physical details on account of their possible connexion (that of the faculæ especially) with the "red flames," and trust that the result may be comparable with the observations of those in Spain who witnessed these remarkable appearances, and determined their apparent position on the solar limb.

The Eclipse.—The moment of first contact was, I believe, at $9^h\ 26^m\ 55^s$ L.S.T. = $1^h\ 40^m\ 45^s$ L.M.T. The moon's advancing limb was exceedingly rugged, four high mountains being very conspicuous. It is a curious fact that the moon appeared to have the effect of stilling the undulations of the solar limb at the points where she cut it. At $9^h\ 43^m\ 23^s$ L.S.T. = $1^h\ 57^m\ 0^s\cdot 3$ L.M.T. the moon's limb centrally covered the group lettered A, and soon afterwards the advance of our satellite disclosed a regular sierra of mountains to the south of those already seen. At $2^h\ 6^m$ L.M.T. I turned the telescope on *Venus*, who was then about 11 hours from her inferior conjunction. She presented an exquisitely beautiful appearance, and her brilliancy was considerably heightened by the relative darkness which prevailed. I send a drawing of the appearance which she exhibited: albeit it is difficult to convey her extreme apparent tenuity faithfully. To return to the sun:—At $10^h\ 24^m\ 18^s$ L.S.T. = $2^h\ 37^m\ 48^s\cdot 6$ L.M.T. the moon's limb was centrally over spot B, whence it steadily advanced and covered spot C centrally at $10^h\ 32^m\ 33^s$ L.S.T. = $2^h\ 46^m\ 2^s\cdot 2$ L.M.T.; not the slightest change was remarked in the aspect of the maculæ, as the moon approached them, both umbræ and penumbræ remaining perfectly sharp and crisp up to the lunar limb. For some time after this the effect of the sunlight, as seen with the naked eye, was very remarkable. A dimness and dullness of a lurid tint seemed to overspread the landscape. Something of the sort might have been produced by a dense veil of mist covering the sun, but the continuation of sunshine and the sharpness of the shadows thrown by posts, rails, and trees, at once must have shown, even to a person ignorant of the eclipse, that this curious diminution of light had no reference to any merely atmospheric cause. The effect of comparative darkness was considerably more striking than on the occasion of the larger eclipse of March 15th, 1858; as, on that day, the dense, impenetrable nimbi only conspired with the obscured sun to give the effect of a dull summer evening; whereas, on the present occasion, this odd unearthly light was coexistent with apparently full sunshine. I may add that a curious and instructive effect of irradiation was presented at

this time, when any temporary passing cloud enabled the observer to regard the sun with the naked eye, or with a pale tinted glass. Under such circumstances, the moon's limb appeared to cut off scarcely one-third of the solar disk; and it was only on reference to the telescope, or on the employment of a glass sufficiently darkened, that the illusion was dispelled, and it was seen that in reality the sun was more than two-thirds obscured. At $10^{h}\ 4^{m}\ 8^{s}\cdot 3$ L.S.T. $=$ $3^{h}\ 1^{m}\ 29^{s}\cdot 7$ L.M.T. spot A was again centrally uncovered; and at $11^{h}\ 15^{m}\ 11^{s}$ L.S.T. $=$ $3^{h}\ 28^{m}\ 33^{s}\cdot 2$ L.M.T. the lunar limb was just half off spot C. After this, the clouds which had more or less been scattered over the heavens all day, began to close rapidly over the sun, and, consequently, the emergence of spot B, and the moment of last contact of the limbs of the sun and moon, were invisible. I made a despairing effort to observe the last contact with the whole telescopic aperture, and an eye-piece undefended even by a dark glass, but in vain, the clouds were impenetrable! I observed, as usual, with my Ross equatoreal of 4·2 inches aperture. The map was made with an eye-piece magnifying 115 times and wired in squares of 1′ each. The eclipse was viewed with a power of 74, and throughout the whole aperture of the telescope was employed, and a piece of smoked talc placed within the focus of the object-glass; an arrangement which I find affords an exquisite view of the details of the solar disk, and which obviates the necessity for diminishing the area of the object-glass by diaphragms.



Key to Map of the Sun, July 18, 1860.

(at 1 hour G.M.T.)

A, large Spot (or group in one penumbra) preceding. B and C smaller spots following. *a*, minute group of spots nearly S of A. *b*, minute group of spots S P C. *α*, double facula at a position angle of 64°. *β*, group of faculæ (with maculæ intermixed, just coming on to the sun's disk) at an angle of 115°. *γ*, another double facula at 246°. *δ* a facula in the form of a "Prince Rupert's drop," at an angle of 289°. The angles are measured from the north point round by the E, S & W, as in the common position micrometer, and are subject to a probable error of $\pm 1°$.

Observed at Uckfield, Sussex, by C. Leeson Prince, Esq.

On the morning of July 18th, 1860, the sky was densely overcast, and some heavy showers fell at intervals before 9 A.M. At 10 A.M. the sky still remained obscured, and it was not until about 10^{h} 40^{m} that a patch of blue sky becoming visible over the Downs, gave some hope that a glimpse of the eclipse might, perhaps, be obtained. At 11^{h} 30^{m} the sky was about half covered by cloud. At noon the whole of the southern sky was almost free from cloud, and, with the exception of an occasional broken cumulus passing before the sun, the sky remained clear till a little past 3 P.M.

The major portion of the phenomenon was seen to great advantage in this latitude. The atmosphere was found to be remarkably diaphanous, and not the slightest tremor could be observed upon the edge of the solar disk. The faculæ and spots were seen beautifully defined.

As a prelude to any notes of the time of contact, I will remark that my observatory is situated 200 feet above the level of the sea, in latitude 50° 58′ 25″ North, and in longitude 0^{h} 0^{m} $24^{s}{\cdot}3$ East. My equatoreal telescope has an aperture of 6·8 inches, and a focal length of 12 feet.

By applying a Dawes eye-piece to a power of 140, I was enabled to use very satisfactorily the whole aperture of the object-glass. The first contact happened exactly at 9^{h} 27^{m} 6^{s} local sidereal time; and I almost immediately observed two remarkable lunar peaks enter upon the sun's disk, and as nearly as possible at the point of contact.

The following notes of time I took with great care:—

	Large Spot. Local Sid. Time.	Spot West of two. Local Sid. Time.	Spot East of two. Local Sid. Time.
	h m s	h m s	h m s
First contact with Penumbra	9 41 47	10 23 53	10 31 52
,, with Spot	9 43 3	10 24 14	10 32 14
Spot occulted	9 43 46	10 24 40	10 33 4
Penumbra occulted	9 44 31	10 24 54	10 33 19

At the time of greatest obscuration the horns of the crescent were particularly sharp and well defined, without the least sign of distortion which could be attributed to a supposed lunar atmosphere. The diminution of light was very considerable, and objects at a short distance appeared enveloped in a grayish blue haze, somewhat similar to the peculiar hue cast upon the landscape on a hot summer day, just after the sun has been obscured by a dense mass of cumulo-stratus cloud threatening a hasty shower. Soon after 3 P.M. clouds gradually came up from the south-west, and from 3^{h} 30^{m} the sun was entirely obscured during the remainder of the eclipse. I imagined that the last contact could not have been seen in this county.

Uckfield, Sussex, Oct. 20, 1860.

Observed at Highbury, by T. W. Burr, Esq.

Being unable to leave England at the time of the Eclipse, I made such observations of the attendant phenomena as the weather permitted. The morning was exceedingly unfavourable, but about noon considerable improvement took place, the sun being visible, though the sky still remained cloudy. From one o'clock to half-past it was very fine, but as the time for the commencement of the eclipse approached the clouds closed and the first contact was lost, the sun not being seen again till $1^h 49^m 31^s$, G.M.T., when the moon had made some progress on its disk. I had intended making a careful diagram from measures of the sun's appearance before the eclipse, upon which its successive phases could have been indicated; but there was no opportunity for doing this work. There were three conspicuous spots, or rather clusters, on the sun's face; one, the largest and most complex, near the south-east limb (as seen in the inverting telescope), and the other two near the north-west and west parts of the disk. Having failed to catch the first impression of the moon's limb on the sun, the next thing was to obtain as many time-observations of the passage over the spots as possible; and the contact of the moon with the penumbra of the first and largest cluster of spots took place at $1^h 54^m 10^s\cdot6$ G.M.T. At $1^h 55^m 30^s\cdot3$ the largest nucleus of this mass was reached, and by $1^h 56^m 20^s$ the whole of the nuclei in this cluster were covered. The disk being now clear for a considerable space, attention was directed to the appearance of the moon's limb, which was distinctly seen to be very rough and serrated; while both it and the sun's edge were in a state of great undulation, and it was perfectly obvious that had the two disks been concentric, the uneven edge of the moon, with its prominences and depressions exaggerated by the "boiling" and irradiation, would almost certainly have produced the effect of rendering "Baily's beads" visible at the two points of contact. I was also particularly struck at this time ($2^h 25^m$) by seeing a portion of the moon visible beyond the part where it was projected on the sun. This was evident at both places where it cut the disk, but more particularly at the upper cusp. The moon's body was visible for about $4'$ from the sun's border, and was seen, not by any light proceeding from it, but by its intense blackness as compared with the sky background. The impression on the eye was not a transient one, but was seen, whenever the eclipse was visible, for half an hour from this time. At $2^h 35^m 51^s\cdot5$ the penumbra of the second spot was reached, and by $2^h 36^m 43^s$ the spot and penumbra were covered. Dense clouds then covered the heavens until after the greatest obscuration, and nothing could be noted but the terrestrial appearances. These were sufficiently striking:—a gradual gloom had come over the scenery, the clouds having a lurid character similar to an impending thun-

derstorm; they were very dark, and seemed lower than usual; in fact, they gave the impression of a rapid descent on the earth. The wind blew strongly from the south-west, and produced an unpleasant and unusual chilliness. Near the zenith a few breaks showed the sky of a deep indigo hue, while towards the horizon, which was very indistinct, the clouds had a copper-coloured tinge. Birds appeared to be returning to the trees from their excursions, and were noticeably silent during the greatest gloom. By $3^h\ 5^m$ most of these peculiar effects were gone; the clouds had become light and silvery, the sky between them pale blue, and the wind lowered. The passage of the obscurity from the north-west to the south-east could also be distinctly traced. The temperature now began to rise from the depression it had suffered. During the brightest part of the morning, about $1^h\ 30^m$, the thermometer had reached $71^{\circ}\cdot5$; it fell gradually during the eclipse to $2^h\ 50^m$, when it stood at $61^{\circ}\cdot5$, and afterwards recovered the elevation of 65° by four o'clock, when the eclipse was over. The passage of the moon again became visible, and at $2^h\ 58^m\ 29^s\cdot9$ a very small spot, below the large one, was uncovered. In another minute the nucleus of the large spot began to emerge, and by $3^h\ 0^m\ 19^s$ was quite clear. At $3^h\ 0^m\ 54^s\cdot4$ the penumbra of this cluster was entirely visible. Clouds again intervened, and when they had passed, the second spot was clear; and at $3^h\ 42^m\ 52^s\cdot5$ the nucleus of the third spot appeared. I was very desirous of getting an observation of the time of the last contact, but the clouds deprived me of it. I saw the moon still projected on the sun at $3^h\ 52^m\ 38^s\cdot9$, and evidently within a few seconds of leaving it; but a cloud once more covered them, and when the sun reappeared at $3^h\ 54^m\ 25^s$, the eclipse had passed. My observations were made throughout with my usual instrument, the equatoreal by Ross, of $3\frac{1}{8}$ inches aperture, at first with direct vision and a power of 58; but after the largest spot was passed, a Hodgson reflector was used, with a power of 100. The latitude and longitude of my observatory are $51^{\circ}\ 33'\ 42''\cdot1$ N. and $23^s\cdot9$ W.

August 1860.

Observed at Haddenham, Bucks, by the Rev. W. R. Dawes.

The solar eclipse of July 18 was observed here under remarkably favourable circumstances until the greatest obscuration was past, when the thin and detached clouds, which had prevailed during the earlier part of the afternoon, thickened so much as completely to obscure the termination of the eclipse.

The first impression on the sun's edge was made by the highest part, near the southern extremity, of the remarkable chain of hills on the moon's eastern limb, named "The D'Alembert Mountains" in the Rev. T. W. Webb's excellent index

map, in his very useful little work entitled *Celestial Objects for Common Telescopes*. During nearly the whole time that the eclipse was visible the image was unusually tranquil, and so distinct, even through the thin stratum of cloud which often covered it, that on my $8\frac{1}{4}$-inch object-glass powers of from 145 to about 520 were employed with excellent effect. The most minute and delicate feathery portions of the penumbra of the large spot in the sun's north-western quadrant were thus brought out with admirable distinctness, and their occultation by the moon's sharply defined edge was most carefully watched. Neither on these, nor on the darker part, (or *umbra*,) of the spot, was the slightest effect produced, either in form or shade, previous to their disappearance.

The moon's limb, just off the disk of the sun and close to it, was repeatedly examined by placing portions of it in a small field of my solar eye-piece, from which the sun was excluded, and using as light a shade as my eye could comfortably bear. No light on any part of the moon's edge could be even suspected.

About the time of the greatest obscuration a very thin cloud near the sun to the south displayed extraordinarily vivid prismatic colours, through a part of which the planet *Venus*, then very nearly at her inferior conjunction, appeared of a delicate pink. This planet was visible through the cloud when the aperture of the finder was reduced to half an inch; and in a clear sky, with an aperture of only $0^{\text{in}}\cdot36$, she looked like a semicircular nebula. Her distance from the sun's southern limb was about 5°.

Haddenham, Thame, Nov. 1860.

Communications were also received from—

Mr. F. Morton, at the Wrottesley Observatory. On account of the unfavourable state of the weather the first contact could not be seen, but the last contact was observed to take place at $3^{h}\ 41^{m}\ 56^{s}$, Wrottesley mean time; but as it was seen through the edge of a cloud the time is considered as uncertain to the extent of about one second.

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The Society has been favoured with a communication from Thomas Frazer, Esq., Secretary of the Hudson's Bay Company, enclosing Reports of Observations of the Eclipse, made by several of the officers of the Company, J. Mackenzie, at Moose Factory, Chief Trader R. Hamilton, at Great Whale River; Chief Trader J. R. Clare, at York Factory; J. P. Gardiner, at Churchill; and Will. Simpson, at Fort Churchill. But the want of instruments and the general unfavourable state of the weather were impediments in the way of any precise observations.

Papers were also received from the Astronomer Royal for Scotland and from Mr. Carrington, containing the determination of the positions of the principal spots near the circumference of the sun's disk, as well on the visible as the invisible hemisphere, at the time of the eclipse.

Results of Meridional Observations of Small Planets and Occultations of Stars by the Moon, observed at the Royal Observatory, Greenwich, from June to October 1860.

(*Communicated by the Astronomer Royal.*)

Metis (9).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 5 4·0	21 47 26·76	......
22	11 35 32·4	21 41 29·68	113 34 7·38
27	11 11 5·0	21 36 41·06	113 55 17·52
31	10 51 43·8	21 33 2·84	114 8 51·50
Sept. 1	10 46 55·3	21 32 10·14	114 11 50·14
11	10 0 2·0	21 24 34·66	114 30 29·09
12	9 55 28·8	21 23 57·23	114 31 10·21
19	9 24 21·4	21 20 20·66	114 31 1·77
Oct. 2	8 30 31·8	21 17 37·32	114 7 49·83
4	8 22 42·9	21 17 40·29	114 1 53·55
8	8 7 27·2	21 18 8·25	113 48 10·93
11	7 56 19·1	21 18 48·07	113 36 26·52
17	7 34 50·3	21 20 55·03	113 9 22·71
20	7 24 28·2	21 22 20·85	112 54 15·85
26	7 4 26·3	21 25 55·04	112 20 46·75
29	6 54 45·2	21 28 2·00	112 2 40·64
30	6 51 34·1	21 28 46·89	111 56 27·49

Flora ⑧.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 57 19·9	3 56 17·11	80 35 22·96

Irene ⑭.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	11 38 2·9	21 20 21·22	117 0 41·79
17	11 33 12·6	21 19 26·74	117 5 16·03
22	11 9 8·1	21 15 1·06	117 26 1·34
Sept. 6	9 59 8·8	21 3 58·53	118 2 30·63
12	9 32 27·4	21 0 52·08	118 6 24·64
Oct. 4	8 2 33·7	20 57 27·78	117 35 29·23

Eunomia ⑮.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 8 54·7	21 51 18·13	90 50 56·07
17	12 4 0·0	21 50 19·11	90 50 5·29
22	11 39 24·4	21 45 22·31	90 47 38·64
27	11 14 53·7	21 40 30·36	90 48 16·78
29	11 5 10·9	21 38 39·04	90 49 18·67
30	11 0 17·6	21 37 41·54	90 49 59·32
31	10 55 27·2	21 36 46·83	90 50 44·17
Sept. 1	10 50 37·4	21 35 52·84	90 51 39·29
10	10 7 58·7	21 28 36·09	91 2 16·21
11	10 3 20·9	21 27 54·10	91 3 39·61
12	9 58 44·7	21 27 13·68	91 5 10·89
13	9 54 10·0	21 26 34·75	91 6 38·71
14	9 49 36·7	21 25 57·30	91 8 13·04
19	9 27 16·2	21 23 15·91	91 15 55·59
Oct. 2	8 32 45·2	21 19 51·16	91 33 13·28
3	8 28 46·9	21 19 48·76	91 34 11·67
5	8 20 55·9	21 19 49·55	91 35 57·52
8	8 9 23·5	21 20 4·93	91 38 4·51
9	8 5 36·7	21 20 14·04	91 38 40·29
11	7 58 8·3	21 20 37·52	91 39 26·95
20	7 26 0·4	21 23 53·32	91 38 33·54
22	7 19 8·3	21 24 53·20	91 37 10·11
26	7 5 52·4	21 27 21·37	91 33 8·50

Fortuna (19).

Mean Solar Time of Observation.		Apparent R. A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 12 55·2	3 11 45·12	72 34 8·34

Calliope (22).

Mean Solar Time of Observation.		Apparent R. A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, June 14	10 54 46·3	16 28 34·41	114 24 47·10

Euterpe (27).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 3	12 8 43·6	1 0 21·55	86 41 44·15
16	11 5 22·6	0 48 5·37	87 55 51·12
17	11 0 32·4	0 47 10·88	88 1 3·44
18	10 55 42·6	0 46 16·87	88 6 10·62
20	10 46 5·6	0 44 31·43	88 15 58·44

Bellona (28).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 17	9 48 13·3	19 34 10·12	106 39 34·93
Sept. 19	7 32 24·2	19 28 5·04	108 32 7·55

Amphitrite (29).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 29 22·7	3 28 15·30	63 22 28·19
29	12 46 17·7	3 20 32·28	63 17 7·05

Harmonia (40).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 20	10 20 5·4	18 15 43·94	114 50 3·39

Isis (42).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 6	11 52 16·5	18 52 58·39	118 45 57·04
14	11 13 17·1	18 45 25·04	119 47 29·36
Aug. 17	8 45 56·4	18 31 42·99	122 11 48·26

Europa (52).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 4	11 8 19·3	20 3 14·11	109 8 24·99

Observed at Highbury, by T. W. Burr, Esq.

Being unable to leave England at the time of the Eclipse, I made such observations of the attendant phenomena as the weather permitted. The morning was exceedingly unfavourable, but about noon considerable improvement took place, the sun being visible, though the sky still remained cloudy. From one o'clock to half-past it was very fine, but as the time for the commencement of the eclipse approached the clouds closed and the first contact was lost, the sun not being seen again till $1^h 49^m 31^s$, G.M.T., when the moon had made some progress on its disk. I had intended making a careful diagram from measures of the sun's appearance before the eclipse, upon which its successive phases could have been indicated; but there was no opportunity for doing this work. There were three conspicuous spots, or rather clusters, on the sun's face; one, the largest and most complex, near the south-east limb (as seen in the inverting telescope), and the other two near the north-west and west parts of the disk. Having failed to catch the first impression of the moon's limb on the sun, the next thing was to obtain as many time-observations of the passage over the spots as possible; and the contact of the moon with the penumbra of the first and largest cluster of spots took place at $1^h 54^m 10^s{\cdot}6$ G.M.T. At $1^h 55^m 30^s{\cdot}3$ the largest nucleus of this mass was reached, and by $1^h 56^m 20^s$ the whole of the nuclei in this cluster were covered. The disk being now clear for a considerable space, attention was directed to the appearance of the moon's limb, which was distinctly seen to be very rough and serrated; while both it and the sun's edge were in a state of great undulation, and it was perfectly obvious that had the two disks been concentric, the uneven edge of the moon, with its prominences and depressions exaggerated by the "boiling" and irradiation, would almost certainly have produced the effect of rendering "Baily's beads" visible at the two points of contact. I was also particularly struck at this time ($2^h 25^m$) by seeing a portion of the moon visible beyond the part where it was projected on the sun. This was evident at both places where it cut the disk, but more particularly at the upper cusp. The moon's body was visible for about $4'$ from the sun's border, and was seen, not by any light proceeding from it, but by its intense blackness as compared with the sky background. The impression on the eye was not a transient one, but was seen, whenever the eclipse was visible, for half an hour from this time. At $2^h 35^m 51^s{\cdot}5$ the penumbra of the second spot was reached, and by $2^h 36^m 43^s$ the spot and penumbra were covered. Dense clouds then covered the heavens until after the greatest obscuration, and nothing could be noted but the terrestrial appearances. These were sufficiently striking:—a gradual gloom had come over the scenery, the clouds having a lurid character similar to an impending thun-

derstorm; they were very dark, and seemed lower than usual; in fact, they gave the impression of a rapid descent on the earth. The wind blew strongly from the south-west, and produced an unpleasant and unusual chilliness. Near the zenith a few breaks showed the sky of a deep indigo hue, while towards the horizon, which was very indistinct, the clouds had a copper-coloured tinge. Birds appeared to be returning to the trees from their excursions, and were noticeably silent during the greatest gloom. By $3^h\ 5^m$ most of these peculiar effects were gone; the clouds had become light and silvery, the sky between them pale blue, and the wind lowered. The passage of the obscurity from the north-west to the south-east could also be distinctly traced. The temperature now began to rise from the depression it had suffered. During the brightest part of the morning, about $1^h\ 30^m$, the thermometer had reached $71^\circ{\cdot}5$; it fell gradually during the eclipse to $2^h\ 50^m$, when it stood at $61^\circ{\cdot}5$, and afterwards recovered the elevation of 65° by four o'clock, when the eclipse was over. The passage of the moon again became visible, and at $2^h\ 58^m\ 29^s{\cdot}9$ a very small spot, below the large one, was uncovered. In another minute the nucleus of the large spot began to emerge, and by $3^h\ 0^m\ 19^s$ was quite clear. At $3^h\ 0^m\ 54^s{\cdot}4$ the penumbra of this cluster was entirely visible. Clouds again intervened, and when they had passed, the second spot was clear; and at $3^h\ 42^m\ 52^s{\cdot}5$ the nucleus of the third spot appeared. I was very desirous of getting an observation of the time of the last contact, but the clouds deprived me of it. I saw the moon still projected on the sun at $3^h\ 52^m\ 38^s{\cdot}9$, and evidently within a few seconds of leaving it; but a cloud once more covered them, and when the sun reappeared at $3^h\ 54^m\ 25^s$, the eclipse had passed. My observations were made throughout with my usual instrument, the equatoreal by Ross, of $3\frac{3}{8}$ inches aperture, at first with direct vision and a power of 58; but after the largest spot was passed, a Hodgson reflector was used, with a power of 100. The latitude and longitude of my observatory are $51^\circ\ 33'\ 42''{\cdot}1$ N. and $23^s{\cdot}9$ W.

August 1860.

Observed at Haddenham, Bucks, by the Rev. W. R. Dawes.

The solar eclipse of July 18 was observed here under remarkably favourable circumstances until the greatest obscuration was past, when the thin and detached clouds, which had prevailed during the earlier part of the afternoon, thickened so much as completely to obscure the termination of the eclipse.

The first impression on the sun's edge was made by the highest part, near the southern extremity, of the remarkable chain of hills on the moon's eastern limb, named "The D'Alembert Mountains" in the Rev. T. W. Webb's excellent index

map, in his very useful little work entitled *Celestial Objects for Common Telescopes*. During nearly the whole time that the eclipse was visible the image was unusually tranquil, and so distinct, even through the thin stratum of cloud which often covered it, that on my 8¼-inch object-glass powers of from 145 to about 520 were employed with excellent effect. The most minute and delicate feathery portions of the penumbra of the large spot in the sun's north-western quadrant were thus brought out with admirable distinctness, and their occultation by the moon's sharply defined edge was most carefully watched. Neither on these, nor on the darker part, (or *umbra*,) of the spot, was the slightest effect produced, either in form or shade, previous to their disappearance.

The moon's limb, just off the disk of the sun and close to it, was repeatedly examined by placing portions of it in a small field of my solar eye-piece, from which the sun was excluded, and using as light a shade as my eye could comfortably bear. No light on any part of the moon's edge could be even suspected.

About the time of the greatest obscuration a very thin cloud near the sun to the south displayed extraordinarily vivid prismatic colours, through a part of which the planet *Venus*, then very nearly at her inferior conjunction, appeared of a delicate pink. This planet was visible through the cloud when the aperture of the finder was reduced to half an inch; and in a clear sky, with an aperture of only $0^{in}\cdot36$, she looked like a semicircular nebula. Her distance from the sun's southern limb was about 5°.

Haddenham, Thame, Nov. 1860.

Communications were also received from—

Mr. F. Morton, at the Wrottesley Observatory. On account of the unfavourable state of the weather the first contact could not be seen, but the last contact was observed to take place at $3^h\ 41^m\ 56^s$, Wrottesley mean time; but as it was seen through the edge of a cloud the time is considered as uncertain to the extent of about one second.

John M. Stodhart, at Dublin; the morning was so cloudy that all idea of telescopic observations was abandoned, and the only observations obtained were of the barometer and thermometer.

C. B. Chalmers, Shanty Bay, County of Simcoe, Canada West. The first and last contacts are stated to have been well observed, and the occultations and emergencies of several spots were also observed, but the times were obtained to minutes only.

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(*Communicated by the Astronomer Royal.*)

Metis ⑨.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 5 4·0	21 47 26·76	......
22	11 35 32·4	21 41 29·68	113 34 7·38
27	11 11 5·0	21 36 41·06	113 55 17·52
31	10 51 43·8	21 33 2·84	114 8 51·50
Sept. 1	10 46 55·3	21 32 10·14	114 11 50·14
11	10 0 2·0	21 24 34·66	114 30 29·09
12	9 55 28·8	21 23 57·23	114 31 10·21
19	9 24 21·4	21 20 20·66	114 31 1·77
Oct. 2	8 30 31·8	21 17 37·32	114 7 49·83
4	8 22 42·9	21 17 40·29	114 1 53·55
8	8 7 27·2	21 18 8·25	113 48 10·93
11	7 56 19·1	21 18 48·07	113 36 26·52
17	7 34 50·3	21 20 55·03	113 9 22·71
20	7 24 28·2	21 22 20·85	112 54 15·85
26	7 4 26·3	21 25 55·04	112 20 46·75
29	6 54 45·2	21 28 2·00	112 2 40·64
30	6 51 34·1	21 28 46·89	111 56 27·49

Flora ⑧.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 57 19·9	3 56 17·11	80 35 22·96

Irene ⑭.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	11 38 2·9	21 20 21·22	117 0 41·79
17	11 33 12·6	21 19 26·74	117 5 16·03
22	11 9 8·1	21 15 1·06	117 26 1·34
Sept. 6	9 59 8·8	21 3 58·53	118 2 30·63
12	9 32 27·4	21 0 52·08	118 6 24·64
Oct. 4	8 2 33·7	20 57 27·78	117 35 29·23

Eunomia ⑮.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 8 54·7	21 51 18·13	90 50 56·07
17	12 4 0·0	21 50 19·11	90 50 5·29
22	11 39 24·4	21 45 22·31	90 47 38·64
27	11 14 53·7	21 40 30·36	90 48 16·78
29	11 5 10·9	21 38 39·04	90 49 18·67
30	11 0 17·6	21 37 41·54	90 49 59·32
31	10 55 27·2	21 36 46·83	90 50 44·17
Sept. 1	10 50 37·4	21 35 52·84	90 51 39·29
10	10 7 58·7	21 28 36·09	91 2 16·21
11	10 3 20·9	21 27 54·10	91 3 39·61
12	9 58 44·7	21 27 13·68	91 5 10·89
13	9 54 10·0	21 26 34·75	91 6 38·71
14	9 49 36·7	21 25 57·30	91 8 13·04
19	9 27 16·2	21 23 15·91	91 15 55·59
Oct. 2	8 32 45·2	21 19 51·16	91 33 13·28
3	8 28 46·9	21 19 48·76	91 34 11·67
5	8 20 55·9	21 19 49·55	91 35 57·52
8	8 9 23·5	21 20 4·93	91 38 4·51
9	8 5 36·7	21 20 14·04	91 38 40·29
11	7 58 8·3	21 20 37·52	91 39 26·95
20	7 26 0·4	21 23 53·32	91 38 33·54
22	7 19 8·3	21 24 53·20	91 37 10·11
26	7 5 52·4	21 27 21·37	91 33 8·50

Fortuna ⑲.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 12 55·2	3 11 45·12	72 34 8·34

Calliope ㉒.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, June 14	10 54 46·3	16 28 34·41	114 24 47·10

Euterpe ㉗.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 3	12 8 43·6	1 0 21·55	86 41 44·15
16	11 5 22·6	0 48 5·37	87 55 51·12
17	11 0 32·4	0 47 10·88	88 1 3·44
18	10 55 42·6	0 46 16·87	88 6 10·62
20	10 46 5·6	0 44 31·43	88 15 58·44

Bellona ㉘.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 17	9 48 13·3	19 34 10·12	106 39 34·93
Sept. 19	7 32 24·2	19 28 5·04	108 32 7·55

Amphitrite ㉙.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 29 22·7	3 28 15·30	63 22 28·19
29	12 46 17·7	3 20 32·28	63 17 7·05

Harmonia ㊵.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 20	10 20 5·4	18 15 43·94	114 50 3·39

Isis ㊷.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 6	11 52 16·5	18 52 58·39	118 45 57·04
14	11 13 17·1	18 45 25·04	119 47 29·36
Aug. 17	8 45 56·4	18 31 42·99	122 11 48·26

Europa ㊾.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 4	11 8 19·3	20 3 14·11	109 8 24·99

Planet (59).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Sept. 18	12 43 16·8	0 35 52·15	89 44 35·45
19	12 38 41·2	0 35 12·32	89 53 44·98
25	12 10 54·9	0 31 0·78	90 49 15·43
Oct. 3	11 33 41·1	0 25 13·32	92 2 4·09
16	11 33 58·2	0 16 35·80	93 46 0·28
17	10 29 28·3	0 16 1·69	93 52 50·96

All the observations of N.P.D. have been corrected for parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			h m s	
1860, Sept. 6	27 Tauri, disapp.	Bright	12 32 19·6	C.
6	27 Tauri, disapp.	Bright	12 32 12·8 (*a*)	J. C.
6	28 Tauri, disapp.	Bright	12 34 40·0	E.
6	η Tauri, reapp.	Dark	12 49 41·0	E.
6	η Tauri, reapp.	Dark	12 49 40·4	J. C.
6	27 Tauri, reapp.	Dark	13 37 24·3	E.
6	27 Tauri, reapp.	Dark	13 37 25·5	J. C.
6	28 Tauri, reapp.	Dark	13 43 40·7	E.
6	28 Tauri, reapp.	Dark	13 43 40·2	J. C.

(*a*), Uncertain to about half a second.

The initials E. and J. C. are those of Mr. Ellis and Mr. Carpenter.

Elements of Planet (59), determined from the meridian observations made with the Transit Circle at the Royal Observatory, Greenwich, on Sept. 18, *Oct.* 3, *and Oct.* 16. By Mr. W. Ellis, Assistant at the Royal Observatory, Greenwich.

	° ′ ″	
Mean Anomaly	350 56 49·2	1860, Oct. 2, 12^h G.M.S.T.
Long. of Perih.	18 55 46·7	Mean Equinox 1860·0
,, Asc. Node	170 18 17·0	Mean Equinox 1860·0
Inclination	8 36 30·5	
ϕ	6 49 30·6	
Log *a*	0·4336174	
μ	793″·561	

Approximate Ephemeris, calculated from the Elements above.

For Greenwich Mean Noon.

1860.		Apparent R.A. h m s	Apparent N.P.D. ° ′	Log. Δ
Nov.	5	0 9 18	95 20·2	0·1973
	6	9 10	95 22·6	
	7	9 4	95 24·8	
	8	9 0	95 26·8	
	9	8 57	95 28·5	0·2072
	10	8 56	95 30·0	
	11	8 56	95 31·2	
	12	8 58	95 32·2	
	13	9 2	95 33·0	0·2175
	14	9 7	95 33·6	
	15	9 14	95 34·0	
	16	9 22	95 34·1	
	17	9 32	95 34·0	0·2281
	18	9 43	95 33·6	
	19	9 56	95 33·1	
	20	10 11	95 32·4	
	21	10 27	95 31·4	0·2390
	22	10 44	95 30·2	
	23	11 3	95 28·9	
	24	11 24	95 27·3	
	25	11 46	95 25·5	0·2501
	26	12 9	95 23·5	
	27	12 34	95 21·4	
	28	13 1	95 19·1	
	29	13 28	95 16·5	0·2613
	30	13 58	95 13·8	
Dec.	1	14 28	95 10·9	
	2	15 0	95 7·8	
	3	15 33	95 4·5	0·2724
	4	16 7	95 1·1	
	5	16 43	94 57·5	
	6	17 20	94 53·8	
	7	17 59	94 49·8	0·2835
	8	18 38	94 45·7	
	9	19 19	94 41·4	
	10	20 1	94 37·0	
	11	20 45	94 32·6	0·2945
	12	21 29	94 27·9	
	13	22 15	94 23·0	
	14	23 2	94 18·0	

1860.	Apparent R.A. h m s	Apparent N.P.D. ° ′	Log. Δ
Dec. 15	23 50	94 12·9	0·3055
16	24 39	94 7·6	
17	25 29	94 2·2	
18	26 21	93 56·7	
19	27 13	93 51·0	0·3162
20	28 7	93 45·3	
21	29 1	93 39·4	
22	29 57	93 33·4	
23	30 53	93 27·2	0·3269
24	31 51	93 20·9	
25	32 49	93 14·5	
26	33 49	93 8·0	
27	34 49	93 1·5	0·3372
28	35 50	92 54·9	
29	36 53	92 48·1	
30	37 56	92 41·2	
31	0 38 59	92 34·2	0·3474

Nov. 7.

Remarkable Changes observed in the Cluster 80 *Messier.* By Norman Pogson, Esq., Director of the Hartwell Observatory.

(*Communicated by Dr. Lee.*)

This fine globular object, although described as "a compressed cluster," had, until this year, always presented the appearance of a well-defined nebula to my eye, under the moderate powers with which I have been accustomed to behold it. As it comes in the same field of view with M. Chacornac's pair of variable stars, R and S *Scorpii*, it has been under regular inspection for the last seven years; from 1853 to 1856 by the French astronomer, and since 1857 by me also. Admiral Smyth examined it in 1837 and again in 1839, but he, as also Messier, Sir John Herschel, Professors Argelander and D'Arrest, recorded it as either "cometary" or "nebulous."

On the 28th of last May, when searching after the two above-named variable stars, neither of which was then visible, my attention was arrested by the startling appearance of a star of the 7.6 magnitude in the place which the nebula had previously occupied. The power used was 118, on the Hartwell equatoreal; and so recently as May 9th—the last night on which R *Scorpii* was visible—I am able to state positively that the nebula was as usual, and had nothing stellar about it,

with the self-same power and instrument. On June 10th, with power 66, the stellar appearance had nearly vanished, but the cluster yet shone with unusual brilliancy and a marked central condensation. I mentioned this extraordinary phenomenon to Mr. Hind on May 30th, also to Admiral Smyth and Dr. Lee, but pressing and anxious business so distracted my attention about that time that I neglected to announce it *publicly*, and had almost forgotten the occurrence until the arrival of the *Astronomische Nachrichten*, No. 1267, in which Prof. E. Luther of Königsberg corroborated my records, by stating that he and M. Auvers had perceived the change on May 21st, a week earlier than my first note, but only twelve days after it had been seen unchanged and nebulous. On the evening of the 21st Prof. Luther estimated it 6.5 magnitude, M. Auvers 7, (mean 6.8); the following night it appeared about the same, but on the 25th somewhat smaller. My own observation of it, when of the 7.6 magnitude, joins well in with those of the Königsberg astronomers; as also does its disappearance on June 10th.

It is, therefore, incontestably proved, upon the evidence of three witnesses, that, between May 9th and June 10th of this year, the cluster known as 80 *Messier* changed, *apparently*, from a pale cometary looking object, to a well-defined star, fully of the seventh magnitude, and then returned to its usual and original appearance. It seems to me absurd to attribute this phenomenon to actual change in the cluster itself, but it is very singular if a new variable star, the third in the same field of view, should be situated exactly between us and the centre of the cluster. Should such be the true explanation, the mid-way variable star must be similar in nature but of greater range than Mr. Hind's wonderful U *Geminorum*. The cluster should be closely watched in some Southern observatory.

Hartwell Observatory, Oct. 8, 1860.

Magnitude Constants for Fifty-seven of the Minor Planets. By Norman Pogson, Esq., Director of the Hartwell Observatory.

(*Communicated by Dr. Lee.*)

A list of the apparent magnitudes of the minor planets, at the commencement of each month throughout the year, was first supplied for 1857, and has since been given annually. In the third year of its existence it was adopted by the Superintendent of the *Nautical Almanac*, as a suitable addition to the Supplement of that work, and it has since continued to appear therein. The scale of estimation employed is based upon the light ratio 2·512; and the photometric range belong-

ing to any good average telescope is sufficiently defined by the formula:—

Limit of Vision = 9·2 mag. + 5 times log. aperture in inches.

The magnitude of any planet, whose mean distance from the sun is denoted by a, and its actual distances from the sun and earth, as usual, by r and Δ, becomes known by the expression:

$$\text{Magnitude} = \text{M} - 5 \log (a^2 - a) + 5 (\log r + \log \Delta)$$

or putting N for the first two terms:—

$$\text{Magnitude} = \text{N} + 5 (\log r + \log \Delta)$$

The constant M is the mean opposition magnitude; *i.e.* the brilliancy of any planet, if, when in opposition, it and the earth were at their respective mean distances from the sun. The number N is the magnitude such planet would acquire, supposing it, the sun and the earth, to be situated at the three angles of an equilateral triangle, the sides of which equal the earth's mean distance from the sun. The number of estimations upon which these light constants depend is added, and although at least twenty of each will be obtained before *final* values are adopted, there is seldom much risk of great error after four or five nights' careful records have been secured.

The utility of the magnitude ephemeris itself, as a means of saving time and trouble to planetary observers, cannot be too plainly illustrated, and I therefore beg leave to offer two very familiar examples to the notice of the Society. Agreeably to my own experience, I consider that a star or planet, to be satisfactorily observable with a ring or other dark field micrometer, must be at least three-fourths of a magnitude brighter than the limit of vision of the telescope; but that with spider lines, and the smallest amount of requisite illumination, it will be *impossible*, under ordinary conditions, to observe an object less than two entire magnitudes within or brighter than the limit. Thus, on the photometric scale adopted, 12·2 magnitude being the limit of vision for a four-inch aperture, the faintest planet observable with illumination will be a trifle below the tenth magnitude; or, with a ring-micrometer and dark field, will be of the 11.5 magnitude. For the great transit circle of the Royal Observatory, eight inches in aperture, the limit of vision being 13.7 magnitude, planets under the 11.5 magnitude cannot well be observed with illumination; though disappearances behind thick bars might, with difficulty, be noted almost to the thirteenth magnitude.

When the predicted magnitude of a faint planet is brighter than its mean opposition magnitude, it should be well followed up. Thus; *Euphrosyne*, *Atalanta*, *Hestia*, and *Virginia*, may be easily recognised at their next oppositions; while *Polyhymnia*

and *Circe* may be despaired of, except with monster equatoreals and dark field micrometers.

The ephemeris for 1861, based upon the following constants, will be found upon pages 71 and 72 of the Supplement to the *Nautical Almanac* for the year 1864, just issued by Mr. Hind.

Planet.	M.	N.	Obs.	Planet.	M.	N.	Obs.
(1) Ceres	7·7	4·3	14	(31) Euphrosyne	11·6	7·4	4
(2) Pallas	8·0	4·5	16	(32) Pomona	10·7	7·6	7
(3) Juno	8·5	5·3	3	(33) Polyhymnia	11·6	8·0	12
(4) Vesta	6·6	4·1	10	(34) Circe	11·7	8·5	6
(5) Astrea	10·0	6·9	19	(35) Leucothea	12·2	8·3	11
(6) Hebe	8·6	5·9	24	(36) Atalanta	12·9	9·5	5
(7) Iris	8·6	6·0	33	(37) Fides	10·5	7·4	11
(8) Flora	8·9	6·8	22	(38) Leda	11·1	7·8	9
(9) Metis	8·9	6·3	15	(39) Letitia	9·4	6·0	6
(10) Hygeia	9·8	5·6	13	(40) Harmonia	9·1	6·8	14
(11) Parthenope	9·5	6·7	20	(41) Daphne	10·2	7·6	1
(12) Victoria	9·6	7·2	12	(42) Isis	10·5	7·8	18
(13) Egeria	9·9	6·8	12	(43) Ariadne	10·2	8·1	12
(14) Irene	9·7	6·6	15	(44) Nysa	10·3	7·6	7
(15) Eunomia	9·1	5·9	17	(45) Eugenia	10·8	7·5	7
(16) Psyche	10·1	6·3	12	(46) Hestia	11·6	8·6	9
(17) Thetis	10·0	7·2	10	(47) Aglaia	11·2	7·5	9
(18) Melpomene	9·5	7·1	18	(48) Doris	11·0	6·9	7
(19) Fortuna	9·7	6·9	16	(49) Pales	10·8	6·8	13
(20) Massilia	9·3	6·6	14	(50) Virginia	11·9	8·7	5
(21) Lutetia	10·5	7·7	13	(51) Nemausa	10·4	7·9	6
(22) Calliope	10·0	6·3	9	(52) Europa	10·5	6·4	19
(23) Thalia	10·5	7·4	10	(53) Calypso	11·5	8·4	3
(24) Themis	11·0	6·8	5	(54) Alexandra	11·0	7·7	5
(25) Phocea	10·6	8·0	5	(55) Pandora	10·9	7·5	13
(26) Proserpine	10·7	7·5	12	(56) Pseu. Daph.	11·5	8·4	1
(27) Euterpe	9·7	7·2	8	(57) Mnemosyne	10·9	6·8	7
(28) Bellona	10·1	6·7	6				
(29) Amphitrite	9·1	6·1	34				
(30) Urania	10·0	7·5	14				

Hartwell Observatory, Nov. 8, 1860.

On a Photograph of the Sun, taken with the Northumberland Telescope of the Cambridge Observatory. By Professor Challis.

In making the following photographic experiment I was favoured, through the kindness of a friend, with the valuable assistance of Mr. Hardwick, to whose skilful preparation of the collodion sensitized plates, and processes of development, the success of the experiment is mainly to be attributed. For the support of the photographic apparatus a frame, made for lightness of deal and covered with blackened canvass, was prepared, so that it could be readily and firmly attached to the eye-end of the telescope. The form of the frame was in part cylindrical, and in part that of a frustum of a four-sided pyramid, the smaller end of which was provided with grooves for holding the plates. The proper position of the eye-piece was ascertained by adjusting it so as to cast an image of the sun on a sheet of paper put in the place prepared for the sensitized plate; but no attempt was made to allow for the difference of the focal lengths of the telescope for the chemical and luminous rays, which in this mode of experimenting appears to have little effect. The remaining operations were extemporised after Mr. Hardwick's arrival at the observatory on July 28, on which day from 2^h to to 3^h the experiments were made. In the first instance the whole aperture of the object-glass, the diameter of which is $11\frac{3}{4}$ inches, was tried; but the sun's action being found to be far too strong the aperture was greatly reduced, till the diameter finally fixed upon was not more than $1\frac{1}{3}$ in. As no means had been provided for admitting and stopping the sun's rays at the eye-end of the telescope, without causing an injurious amount of tremor, an opaque screen was mounted on a pole and held at a small distance from the object-glass, and on a signal being given, when the plate was in place, the screen was passed and returned so as to expose the aperture to the solar rays as brief an interval as was possible with this mode of operating. It would have been better to have simply moved a slit in the screen across the aperture; for, although the aperture was so much reduced, the sun's action was still too strong.

The focal length of the Northumberland telescope being $19\frac{1}{2}$ ft., the diameter of the image of the sun's disk formed at the focus on the day of the experiment was 2·15 in. The magnifying power of the eye-piece was 100, and the distance of the photographic plate from the focus of the object-glass about 13 inches. By the reduction of the effective aperture the brightness of the focal image was diminished in the ratio of the square of $11\frac{3}{4}$ to the square of $1\frac{1}{3}$, that is, in the ratio of 78 to 1. And as the diameter of the image thrown on the plate was found by measurement to be 11·42 in., the ratio of the brightness of this image to that of the focal image was equal to the square of the ratio of 2·15 to 11·42, that is, to the ratio of 1 to 28

nearly. Although the brightness of the final image was thus made less than that of the focal image formed by the whole aperture of the object-glass, in the ratio of 1 to 2200 nearly, the sun's action during a very small fraction of a second sufficed to produce a very decided impression.

The photographic picture resulting from the experiment (a specimen of which accompanies this note) exhibits a portion of the sun's disk, limited by the boundary of the field of view and by an arc of 43° of the limb, and containing two groups of spots of moderate size. The contrast between the dark nucleus and its surrounding penumbra, and the definite exterior boundary of the latter, are well expressed. About the group which is nearest the limb, the *faculæ* which generally accompany groups in this position are distinctly visible. Also the diminution of the brightness of the sun's disk towards the periphery, which is now an admitted fact, is very manifest in the photograph.

During the experiment the equatoreal was carried by clock-movement. When, however, the time of exposure is as brief as it was in this instance, this movement, which necessarily produces some amount of tremor, may probably with advantage be dispensed with. If at the same time the sun's rays be admitted at the object-glass in the manner above described, instrumental tremor will be completely avoided. The method of admitting the light by suddenly letting fall a diaphragm connected with the telescope is faulty in principle, because the breaking of the connexion is mechanically equivalent to giving an impulse to the telescope. Also if the diaphragm be let fall at the eye-end of the telescope, the light which passes through the slit must, as it crosses the field, be accompanied with diffraction light; whereas if the light be admitted at the object-glass, there is no diffraction light except at the boundary of the field, where it is of no consequence. It is known, from the principles of optics, that in the latter arrangement the *whole* of the image within the field of view is illumined, so long as the sun's rays are not entirely cut off by the diaphragm, and consequently that the illumination advances gradually from zero to a maximum, and passes off as gradually. These would appear to be conditions very favourable to the production of good definition.

Cambridge Observatory, Nov. 8, 1860.

Dévéloppement de la Fonction Perturbatrice en Série. Par M. Kowalski. (Abstract.)

If v, v' are the true anomalies, ω, ω' the distances of the pericentres from the mutual node, and if

$$v - v' + \omega - \omega' = \theta$$
$$v + v' + \omega + \omega' = \psi,$$

then the reciprocal of the distance of the two planets can be developed in the form

$$\frac{1}{\varrho} = \frac{1}{2} \Sigma \, Z_i^{\beta} \cos (i\theta + \beta\psi),$$

where i and β extend from $-\infty$ to ∞ and $Z_i^{-\beta} = Z_i^{\beta}$.

Moreover, if z, z' denote the mean anomalies, and if the general term of the development of $\frac{1}{\varrho}$ is represented by

$$X \cos (\varkappa z - i z' + \eta \omega - \eta' \omega'),$$

where X can be expressed as a definite integral involving the coefficient Z; viz. the general term of X is

$$= \frac{1}{\pi^2} \int_0^{\pi} \int_0^{\pi} Z_{i+q}^{\beta} \cos (\varkappa z - \eta v) \cos (i z' - \eta' v') \, dz \, dz',$$

and the value of the coefficient X is obtained by means of a series of transformations effected upon this definite integral. The memoir has been published in the *Récherches Astronomiques de l'Observatoire de Kasan*, 1859.

Minor Planets (60), (61), (62).

Since the discovery by M. Chacornac of Minor Planet (59), three new Minor Planets have been discovered. As referred to by M. Leverrier (*Comptes Rendus*, 16th Oct. 1860), these are:—

Minor Planet (60), discovered by Mr. Ferguson, at Washington, on the night of the 15th Sept. The observed place was approximately,

	Washington M.T.	R.A.	N.P.D.
1860, Sept. 15	$10^h 22^m 5^s$	$23^h 4^m 30^s.4$	$93° 23' 39''$

Daily motion $-54^s.0$ in Right Ascension and $9'.0$ in North Polar Distance. It was noted on the night of the 14th as one not on Chacornac's Charts; and on the 15th its planetary character became evident. Estimated magnitude 11.

Minor Planet (61), discovered by M. Goldschmidt on the 9th Sept., and recognised as a Planet on the 19th. See last Number of the *Monthly Notices*, where this Planet is referred to as Minor Planet (60). The name *Danaë* has been given to it.

Minor Planet (62), discovered at Berlin by Dr. Forster and M. Lesser. First observed the 14th Sept., but supposed to be M. Chacornac's Planet (59). The continuation of the observations up to the 10th Oct. showed that the Planet was really a distinct one. Estimated magnitude 11. Elements calculated

by MM. Romberg and Tietjen, from the Berlin Observations of the 14th and 24th Sept. and 8th Oct. 1860, (see *Ast. Nach.* No. 1281, where there is also given a slightly different set of elements calculated by Dr. Seeling of the Glasgow Observatory).

Epoch, 1860, Sept. 24,51684.

Mean longitude	334° 55′ 19″	
Excentricity	9 25 52	
Longitude of perihelion......	40 11 4	Mean Equinox of 1860·0.
Longitude of node...	126 56 45	
Inclination	2 14 15	
Diurnal motion	636″·320	
Log. mean distance	0,497554	

The name *Erato* has been given to this planet.

Discovery of a New Comet.

In Leverrier's *Bulletins* of the 25th and 26th Oct. is contained the intelligence of the discovery of a new comet by M. Tempel at Marseilles. The following approximate place is given by M. Villarceau in the *Bulletin* of the 26th Oct.

		R.A.	Decl.
	h m	h m s	° ′
Oct. 25	15 30 Paris	10 5 18	+ 31 26

MISCELLANEOUS INTELLIGENCE.

Mr. Norman Robert Pogson has been appointed Astronomer at the Madras Presidency.

Sir John Herschel has forwarded to one of the Secretaries a letter from Prof. Erman, of Berlin, which he desires to bring before the notice of the Society. The following is the substance of the letter in question:—

"The Prussian Government contemplate erecting a bust of Bessel on the outside of the University-buildings at Königsberg, where it will range with those of other celebrities. The sculptor, Herr Siemering, who has prepared the bust from existing representations of Bessel, wishes to obtain orders for a copy or copies of his work, which is suited for erection in a public place, and is regarded by Prof. Erman as a faithful likeness. At his request, Prof. Erman has forwarded a photograph taken from the original to Sir J. Herschel, desiring

him to bring H. Siemering's proposal before English astronomers, and to say, at the same time, that copies on a reduced scale can be supplied if desired. The original bust is about double life-size. The photograph can be seen at the apartments of the Society."

Address, Herr Bildhauer Siemering, durch H. Geheim Ober-Baurath Stüber, Berlin.

To be sold:—

1. Gregorian reflecting telescope, with 6-inch speculum, on firm iron stand, with equatoreal motion, three eye-glasses ranging in power from 120 to 600.

2. Newtonian reflecting telescope, with 11-inch speculum, on firm iron stand, with two eye-glasses.

For further information, apply to the Assistant-Secretary.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXI. *Dec.* 14, 1860. No. 2.

The Rev. R. Main, President, in the Chair.

Sir Charles Tilstone Bright, 12 Upper Hyde Park Gardens, was balloted for and duly elected a Fellow of the Society.

On a Method for determining Longitude by means of observations on the Moon's greatest Altitude. By William Spottiswoode, Esq., M.A., F.R.S., &c. (Abstract.)

The object of the present investigations is to suggest a method whereby, at certain parts of the moon's orbit, and under favourable circumstances, the longitude may be determined by means of a simple sextant observation. The method does not attain to the same degree of accuracy as some others already in use; nor can it be successfully applied except when the moon's motion in declination is considerable; and the observation, being restricted in time to the immediate vicinity of the greatest altitude, is very dependent on weather. For the traveller supplied with proper instruments, the eclipses of *Jupiter's* satellites will, doubtless, always furnish one of the best means of determining the longitude; and for one carrying only a sextant, the method of lunar distances is superior to all others; but the labour of the latter observations is such as to render them practicable only at rare intervals on a journey, while the complexity of the calculations almost precludes the possibility of obtaining satisfactory results until the data have been sent home. A method, therefore, in which both observation and calculations are simple may not be without use, either as supplementary to more elaborate processes, or as a substitute when

they are not practicable; and the following is suggested for the use of the traveller as a check to his dead reckoning, after the last of his chronometers has broken down, and when results from lunar distances are not attainable.

The method consists in determining the moon's declination at the time of the greatest altitude. This being ascertained, if the local time be known, we have merely to compare the Greenwich time, deduced from the *Nautical Almanac*, at which she has that declination; the difference in times is of course the longitude expressed in time. If, however, the local time be not known, a formula deduced from the same data, and given in the memoir, determines the hour-angle at the time of the greatest altitude. By means of this, the correction to be applied to the moon's declination at the time of observation, in order to reduce it to that on the meridian, may be calculated; and a comparison of the declinations at her meridian passage at the place and at Greenwich, with the aid of the table of differences of declination in the *Nautical Almanac*, will give the longitude.

On the Distribution of the Perihelia of the Parabolic Comets in relation to the Motion of the Solar System in Space. By R. C. Carrington, Esq. (Abstract.)

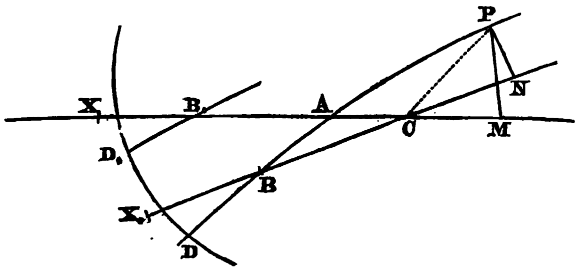
Inquiries into the direction and amount of the motion of the solar system have hitherto been entirely based upon the consideration of the residual small motions of what were once termed the fixed stars; and although the results for direction now exhibit a progressively increasing agreement and certainty, it is always desirable, where the case admits of it, to endeavour to obtain an independent result by approaching the subject from a different point of view. The bearing which the distribution of comets has on the matter was suggested by the observed horary variation in the number of meteors, and the explanation of the probable cause of this variation, given by M. Bompas in the *Monthly Notices* for Jan. 1857, by reference to the orbital motion of the earth. A like idea applies to the distribution of the parabolic comets, and the proposition stands thus:

If the comets moving in unclosed orbits be chance visitors, and if the conditions of visibility on the whole affect the discovery of all alike, it would be expected that, were the Sun at rest, the perihelia would be found equally scattered through the heavens; but if the Sun be in motion, as we now hold it to be, from α *Columbæ* to π and μ *Herculis*, then there would be *found* a certain excess of perihelia in the hemisphere of which

α *Columbæ* is the pole, and a certain condensation about that region, so that if for each orbit the angle were computed between α *Columbæ* and the comet's perihelion, the mean of these angles would be less than 90°. This is tested by the tables annexed to the memoir. It appears that out of the 133 parabolic and hyperbolic orbits considered, the perihelia of 61 lie in the hemisphere from which, and of 72 in the hemisphere to which, the sun is assumed to be moving; the mean angular distance between α *Columbæ* and each perihelion coming out 95° 36′, a result which superior evidence shows must be regarded as nugatory and vitiated by uncontrolled conditions, among which the principal is probably the unequal distribution of discoverers of comets in the northern and southern hemispheres of the earth.

On some Formulæ relating to the Variation of the Plane of a Planet's Orbit. By A. Cayley, Esq.

In Hansen's Memoir, "Auseinandersetzung einer zweckmässigen Methode zur Berechnung der absoluten Störungen der kleinen Planeten," Abh. der k. Sächs. Gesell. t. v. (1856), are contained, § 8, some very elegant formulæ for taking account of the variation of the plane of the orbit. These, in fact, depend upon the following geometrical theorem, viz., if (in the figure) A B C is a spherical triangle; P, a point on the side A B; and P M, P N, the perpendiculars let fall from P on the other two sides A C, C B; then we have



$$\cos PM \sin(BC + CM) = \cos PN \sin BN - \tan \tfrac{1}{2} C \cos BC (\sin PM + \sin PN),$$
$$\cos PM \cos(BC + CM) = \cos PN \cos BN + \tan \tfrac{1}{2} C \sin BC (\sin PM + \sin PN).$$

These equations, in fact, give

$$\cos PM \sin CM = \cos PN \sin CN - \tan \tfrac{1}{2} C (\sin PM + \sin PN),$$
$$\cos PM \cos CM = \cos PN \cos CN;$$

the latter of which is at once seen to be true, since joining the points C and P, the two sides are respectively equal to cos CP. To verify the former one, write $\angle PCM = C_1$, $\angle PCN = C_2$, so that $C = C_1 - C_2$. Then, since $\cos CP = \cos PM \cos CM = \cos PN \cos CN$, $\sin PM = \sin CP \sin C_1$, $\sin PN = \sin CP \sin C_2$, the equation becomes $\cos CP (\tan CM - \tan CN) = -\tan \frac{1}{2} C \sin CP (\sin C_1 + \sin C_2)$, or since $\tan CM = \tan CP \cos C_1$, $\tan CN = \tan CP \cos C_2$, this is

$$\cos C_1 - \cos C_2 = -\tan \tfrac{1}{2} C (\sin C_1 + \sin C_2),$$

which is identically true, in virtue of the equation $C = C_1 - C_2$; and, conversely, we have the original two equations.

Suppose that XM is the ecliptic, X being the origin of longitudes, DP the instantaneous orbit, D the departure-point therein, and P the planet, DD_0 the orthogonal trajectory of the successive positions of the orbit; and writing

$\mathfrak{b}$, the departure of the planet,
v, the longitude of ditto,
y, the latitude of ditto,
θ, the longitude of node,
σ, the departure of ditto,
φ, the inclination;

then, in the figure, $DP = \mathfrak{b}$, $XM = v$, $PM = y$, $XA = \theta$, $DA = \sigma$, $\angle A = \varphi$.

The quantities θ_0, σ_0, φ_0, might be considered as altogether arbitrary; but to fix the ideas it is better to assume at once that they denote

θ_0, the longitude of node,
σ_0, the departure,
φ_0, the inclination,

for the initial position of the orbit, viz., in the figure $XB_0 = \theta_0$, $D_0B_0 = \sigma_0$, $\angle B_0 = \varphi_0$.

Take $DB = \sigma_0$, $\angle B = \varphi_0$, $BX_0 = \theta_0$, this determines a travelling orbit of reference X_0N, and origin of longitudes X_0 therein; such that, with respect to this travelling orbit, the position of the planet's orbit is determined by

θ_0, the longitude of node,
σ_0, the departure of node,
φ_0, the inclination.

We have in the triangle ABC, $AB = \sigma - \sigma_0$, $\angle B = \varphi_0$,

$\angle A = 180^\circ - \varphi$; and if the other parts of the triangle are represented by

$$\begin{aligned} BC &= \omega, \\ AC &= \theta_0 - \theta + \omega + \Gamma, \\ \angle C &= \Phi; \end{aligned}$$

then ω, Γ, Φ, are given in terms of $\sigma - \sigma_0$, φ_0, φ; and we have, moreover, $XC = \theta + AC = \theta_0 + \omega + \Gamma$, $X_0C = \sigma_0 + \omega$; that is, the position of the travelling orbit X_0N, and origin of longitudes X_0 therein, are determined by

$$\begin{aligned} &\theta_0 + \omega + \Gamma, && \text{the longitude of node,} \\ &\sigma_0 + \omega\phantom{{}+\Gamma}, && \text{the departure of node,} \\ &\Phi\phantom{{}+\omega+\Gamma}, && \text{the inclination.} \end{aligned}$$

Suppose that in reference to this travelling orbit and origin of longitudes therein, we have

$$\begin{aligned} &v', && \text{the longitude of planet,} \\ &y', && \text{the latitude of ditto,} \end{aligned}$$

viz., in the figure $X_0N = v'$ (and therefore $BN = v' - \theta_0$), $PN = y'$.

Moreover, $BC + CM = BC + AM - AC = \omega + (v - \theta) - (\theta_0 - \theta + \omega + \Gamma) = v - \theta_0 - \Gamma$, hence the two equations are

$$\begin{aligned} \cos y \sin(v - \theta_0 - \Gamma) &= \cos y' \sin(v' - \theta_0) - \tan\tfrac{1}{2}\Phi \cos\omega\,(\sin y + \sin y'), \\ \cos y \cos(v - \theta_0 - \Gamma) &= \cos y' \cos(v' - \theta_0) + \tan\tfrac{1}{2}\Phi \sin\omega\,(\sin y + \sin y'), \end{aligned}$$

or, as they may also be written,

$$\begin{aligned} \cos y \sin(v - \theta_0 - \Gamma) &= \cos\varphi_0 \sin(\mathfrak{b} - \sigma_0) - \tan\tfrac{1}{2}\Phi \cos\omega\,(\sin y + \sin y'), \\ \cos y \cos(v - \theta_0 - \Gamma) &= \cos(\mathfrak{b} - \sigma_0) + \tan\tfrac{1}{2}\Phi \sin\omega\,(\sin y + \sin y'), \end{aligned}$$

or, if we put $s = \sin y + \sin y'$, then observing that $\sin y = \sin\varphi \sin(\mathfrak{b} - \sigma)$, $\sin y' = \sin\varphi_0 \sin(\mathfrak{b} - \sigma_0)$, these become

$$\left\{\begin{aligned} \cos y \sin(v - \theta_0 - \Gamma) &= \cos\varphi_0 \sin(\mathfrak{b} - \sigma_0) - \tan\tfrac{1}{2}\Phi \,.\, s\cos\omega, \\ \cos y \cos(v - \theta_0 - \Gamma) &= \cos(\mathfrak{b} - \sigma_0) + \tan\tfrac{1}{2}\Phi \,.\, s\sin\omega, \\ \sin y\,[= \sin\varphi\sin(\mathfrak{b} - \sigma)] &= -\sin\varphi_0 \sin(\mathfrak{b} - \sigma_0) + s, \end{aligned}\right.$$

which are, in fact, Hansen's formulæ (16), p. 75, the letters corresponding as follows, viz.,

$$\begin{aligned} &v,\ \mathfrak{b},\ y,\ \sigma,\ \sigma_0,\ \theta,\ \theta_0,\ \varphi,\ \varphi_0,\ \Phi,\ \Gamma,\ \omega\ \text{(suprà) to} \\ &l,\ v,\ b,\ \sigma,\ h,\ \theta,\ h,\ i,\ -k,\ 2n,\ \Gamma,\ \omega\ \text{(Hansen).} \end{aligned}$$

where, of course, the correspondence φ_0 to $-k$, shows that these angles are measured in a contrary direction. I had from Hansen's equations expected that the above formulæ would have contained $\sin y - \sin y'$ in place of $\sin y + \sin y'$.

2 Stone Buildings, W. C., 4th Dec. 1860.

Observations of Comet III. 1860. By W. Scott, Esq., Director of the Observatory of Sydney.

I send you herewith my latest determinations of the comet's position. The weather was too cloudy for observations during the whole of the time intervening, and for many days following.

The light of the comet was too faint and diffused to admit of satisfactory observations, as will appear from a comparison of the results.

Comet Observations, August 1860.

Greenwich Mean Time. d	h m s	Star.	Comet—Star R.A. m s	Comet—Star Decl. ′ ″
Aug. 16	21 32 56·5	φ Centauri	7 34·25	−13 26
	22 37 29·0	,,	7 43·50	10 39
	22 48 51·5	,,	7 47·00	−10 46
17	21 46 44·5		10·25	1 33
	49 39·5		14·00	2 18
	52 39·5		13·00	2 9
	55 29·25		14·25	2 22
	58 8·75		13·00	2 15
	22 1 6·25		13·25	1 59
	3 59·25	Star of 7th or 8th magnitude. Approximate R.A. $13^h 59^m$ Decl. − 42°0. (? 42′ 0″ S. Ed.)	14·50	1 48
	7 1·75		16·00	2 13
	9 45·00		15·75	2 7
	12 35·5		15·75	2 23
	14 58·5		15·75	2 24
	20 48·75		16·25	1 57
	23 25·0		16·75	2 8
	27 2·5		16·50	1 55
	29 53·0		17·00	1 57
	33 0·0		17·25	2 4
	37 45·5		18·00	2 11
	41 30·5		19·00	1 51
	45 37·5		20·00	2 2
	49 1·0		19·00	3 1
	53 53·0		20·25	2 0

Determination of Comet's Position, July 1860.

Greenwich Mean Time.		Star.	Comet — Star. R.A.	Comet — Star. Decl.
d	h m s		m s	′ ″
July 27	22 27 16·0	Bris. 4134	7 47·0	− 0 57
	22 45 7·5	”	7 51·25	− 0 57
	”	Bris. 4136	7 27·75	4 48
	”	Bris. 4139	6 58·50	3 57
	22 55 35·0	Bris. 4134	7 53·00	− 2 15
	”	Bris. 4139	6 58·25	2 4
	”	*a*	2 0·75	13 22
	23 8 43·5	*a*	2 1·75	13 0
	23 13 6·0	*a*	2 4·00	12 25
	”	*b*	−0 16·00	13 8
	23 15 48·0	*b*	−0 14·75	13 13
	23 45 43·5	*b*	−0 7·25	12 18
	48 40·0	*b*	−0 6·50	11 20
	53 32·5	*b*	−0 6·00	11 36
			∗ —B. 4139	∗ —B. 4139
		a	4 57·50	−11 18
		b	7 17·50	−11 58
2	21 14 11·0	Lacaille 5329	1 27·25	−11 58
	17 59·0	”	1 27·00	−12 23
	31 1·0		1 30·00	−12 37
	36 18·5		1 30·75	−13 19
	42 0·0		1 32·00	−13 3
	47 1·5		1 34·00	−12 58
	51 23·5		1 33·00	−13 13
	55 35·0		1 34·25	−13 29
	22 0 1·5		1 35·25	−13 49
	4 10·0		1 36·25	−13 50
	8 13·5		1 37·00	−13 55
	12 13·5		1 37·75	−14 14
	16 20·0		1 39·25	−14 26
	20 30·0		1 40·00	−14 41
	24 38·0		1 40·75	−14 37
	28 39·0	”	1 42·25	−15 1

Observatory, Sydney, Sept. 19*th*, 1860.

Observations of the same comet (III, 1860) taken at Ascension Island by Mr. Frederick J. Krabbe, H.M.S. Meander, between the 4th and the 22d July, 1860, have been communicated to the Society by favour of the Lords Commissioners of the Admiralty. The observations are sextant ones of the distances of the comet from certain fixed stars.

Results of Meridional Observations of Small Planets, and Occultation of Jupiter's third Satellite, observed at the Royal Observatory, Greenwich, during the month of November, 1860.

(*Communicated by the Astronomer Royal.*)

Flora (8).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 1	13 2 1·2	3 48 7·96	81 6 37·94
2	12 57 13·0	3 47 15·51	81 8 52·62
3	12 52 23·5	3 46 21·80	81 10 55·16
7	12 32 52·6	3 42 33·96	81 18 14·66
22	11 18 28·5	3 27 5·93	81 25 3·69

Metis (9).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 2	6 42 9·3	21 31 10·24	111 37 0·60

Eunomia (15).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 2	6 43 33·7	21 32 34·88	91 21 40·55
3	6 40 28·0	21 53 25·25	91 19 33·81

Psyche (16).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 15	12 32 41·4	4 13 55·14	73 44 48·95
22	11 58 57·3	4 7 41·39	74 2 3·80

Fortuna (19).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 1	12 15 50·6	3 1 49·80	73 28 40·73
2	12 10 59·6	3 0 54·55	73 33 40·38
3	12 6 8·2	2 59 58·94	73 38 43·45
7	11 46 40·5	2 56 14·20	73 59 13·43
15	11 7 54·0	2 48 53·86	74 39 37·96

Euterpe (27).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 2	9 45 32·5	0 35 3·60	89 4 10·72
3	9 41 3·4	0 34 30·31	89 6 36·73

Amphitrite (29).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 1	12 31 34·5	3 17 36·32	63 18 51·07
2	12 26 38·0	3 16 35·53	63 19 36·80
3	12 21 41·0	3 15 34·32	63 20 32·60
7	12 1 47·2	3 11 23·39	63 25 49·95
22	10 47 12·1	2 55 44·46	64 4 40·12

Minor Planet (59).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Nov. 3	9 16 10·9	0 9 33·73	95 15 36·35
7	8 59 56·7	0 9 3·06	95 25 27·22

Occultation of Jupiter's Third Satellite.

Day of Observation.	Phenomenon.	Mean Solar Time.	Observer.
		h m s	
1860, Nov. 2	Occ. disapp. first cont.	13 15 50·6	D.
	,, last cont.	13 21 49·6	D.
	Occ. reapp. central bis.	17 1 43·7	A. D.
	,, last cont.	17 5 13·2	A. D.

At the reappearance the planet was very faint, in consequence of a fog prevailing.

The initials D. and A. D. are those of Mr. Donkin and Mr. Davis.

Minor Planet (60).

The name *Titania* has been given to this planet. The following is the later of two sets of elements computed by the discoverer, Mr. Ferguson (*Gould Ast. Journal*, No. 141).

Epoch 1860, Oct. 1, Washington M.T.

	° ′ ″	
Mean longitude	199 48 13·8	
Longitude of perihelion......	158 6 45·7	Mean Equinox of Epoch.
Longitude of node	187 15 15·8	
Inclination	4 40 18·8	
Excentricity	11 27 10·2	
Log. mean distance	0·359725	
Mean motion	1024″·3	

A portfolio of drawings of Solar Spots, by the Rev. F. Howlett, presented by him to the Society, was exhibited at the Meeting. The following is an extract from a letter to Sir J. W. F. Herschel, which accompanied this valuable present:—

"The drawings I now have the honour of submitting to you illustrate (with intermissions, of course, of greater or less duration) the period comprised between 23d Nov. 1859, and 10th Nov. 1860, inclusive; and they consist of about 100 diagrams of the whole solar disk, as seen under a magnifying power of about 30 diameters, and also of some 130 more diagrams of the separate spots, or groups of spots, magnified commonly about 120 diameters.

"It may be seen that many of the drawings were taken at an early hour in the morning, more especially during the months of June, July, and August last past; not only on account of the sky having frequently been very clear and serene at such times, even during this last unusually wet and gloomy summer, but also because the inclination to the horizon of any fixed line on the sun's disk (such as the line of junction of two spots) changes but very slowly in the earlier hours of the forenoon, and is, in fact, for about an hour or so, nearly unaltered; and thus an excellent opportunity was afforded, at such times, for noting down the relative positions of the spots on the sun's disk at greater leisure and with greater accuracy than, with the rough micrometric appliances at my command, I could easily have done at any hour nearer to noon, when the change of the obliquity of the sun's axis to the vertical is very much greater.

"With respect to other points, perhaps of interest in connexion with these diagrams generally, I would remark that the most conspicuous outbursts of spots hitherto this year (so far, at least, as I myself have observed) occurred, firstly, between the 28th June and the 7th, or say 9th of July, as delineated in sheets Nos. xxiii., xxiv., and xxv., wherein also are presented, as well as my 'Dollond' of barely 3 inches aperture enabled me to investigate them, certain of the changes successively undergone by the groups more particularly lettered therein ζ and ι.

"The second principal outburst might be assigned, I think, to the period between 28th July and 8th Sept. (unless indeed the sun's rotation in rather more than twenty-five days may have brought some of the later June and earlier July groups again into sight, and which I certainly am inclined to think was the case), as shown in sheets Nos. xxviii. to xxxii. inclusive; wherein likewise are presented the series of changes undergone by group μ, for instance, in xxviii. and xxix., and still more by ϱ in xxxi. and xxxii. The spot θ in No. xxv. (which also was observable on the day of the solar eclipse in July last) is likewise rather worthy of notice.

"As regards the darkest part of the nucleus of a spot (so

frequently and so distinctly brought out by the Rev. Mr. Dawes' method of investigating them, as stated in your 'Outlines of Astronomy') this phenomenon was very apparent even without any such method, in the spot β of 23d Nov. 1859, in sheet No. ix.; and again, on the 4th and 7th Sept. 1860, in the right-hand nucleus of spot ϵ, in No. xxxii.

"The large spot ζ, of 1st July, 1860, presented a very singular step-like appearance (No. xxiii.). At this period also, as well as on the 28th and 29th June, I observed a nucleus in this group more nearly approaching in form those curious wedge-shaped ones which were represented in my drawings of 28th August, 1859, than any others which have occurred, I believe, since the date just mentioned. The changes undergone by the group ζ, between its first appearance about 27th June and its disappearance, were very striking, more especially in the interval between the 1st and 2d July (see sheets xxiv. and xxv.)

"On the 22d June I noticed near the western limb of the sun a facula which appeared to extend, in a wavy continuous streak, to a length of at least 150,000 miles on the sun's surface, as faintly indicated in the disk of that day in No. xxii.

"The predominance of spots in the sun's northern hemisphere was, perhaps, not so decided this year as usual, though it was sufficiently marked during the great outburst in June and July last."

And appended to the letter was an account of the method adopted for noting down the positions of the spots on the disk; the co-ordinates employed are, in fact, those of Pastorf, viz., the distances in two directions at right angles to each other, of the point from the circumference of the disk. It has already been remarked by Mr. Carrington that the employment of such co-ordinates is anything but convenient.

There were exhibited at the Meeting four photographs of the Sun during the Eclipse of the 18th July, 1860, obtained at Desierto de las Palmas in Spain, by M. Monserrat, Professor of Chemistry at the University of Valentia, with the telescope by Cauchoix of the Observatory of the Collegio Romano, brought by the Director, P. Secchi. The photographs were communicated to the Astronomer Royal by Signor Aguilar, the Director of the Madrid Observatory.

At the Meeting in November were exhibited two lithographic drawings of Nebulæ, accompanied with a printed

description, presented by Mr. Lassell. The one of them represented the Annular Nebula in *Lyra*, R.A. $18^h\ 48^m{\cdot}4$, N.P.D. $57^\circ\ 8'$, as seen in the 4-foot equatoreal, power 174, the field of view being about $5''{\cdot}68$ in diameter, the scale of the drawing was $1'' = 0{\cdot}015$ inch. The greater axis of the nebula is about $89'$, and the lesser about $68''$, by micrometrical measurement. The other drawing was a representation of the "Dumb Bell" Nebula, as seen with the 4-foot equatoreal, and the same power and field of view as was employed in the drawing of the Annular Nebula of *Lyra*.

RECENT PUBLICATIONS.

Recueil de Mémoires des Astronomes de l'Observatoire Centrale de Russie, publié avec l'autorisation de l'Académie des Sciences, t. II. Pet. 1859.

The first volume of this Collection, published 1853, and containing various important memoirs by MM. Struve, Peters, Döllen, Lindhagen, O. Struve, and Liapounov, is well known to astronomers. The present and concluding volume contains memoirs by M. O. Struve on the chronometrical expeditions in the years 1845 and 1846, and on the geographical positions determined by Lieut.-Col. Lemm, in 1847 in the country of the Don Cossacks, and in 1848 in the Government of Novgorod; the volume contains also the Pulkova observations of Biela's comet in the year 1852, with two plates of the comet as seen on the 20th Sept. and the 25th Sept. 1852; for a notice of these observations see *Monthly Notices*, vol. xvi. p. 137. M. O. Struve in the preface states that in consequence of the new regulations adopted by the Academy of Sciences at St. Petersburg, the collection will cease to appear in its actual form, but that a fixed number of copies of the astronomical memoirs will be put at the disposition of the Central Observatory, and that the scientific establishments, and Russian and foreign *savans*, who have received from the Observatory the two volumes of the Collection, will receive each separate astronomical memoir as it is printed, and that the works of the Russian astronomers will thus be more speedily brought to the knowledge of the astronomical public. The two memoirs next referred to have in fact already appeared in the new form; and the preface announces also the speedy publication of two other memoirs, by MM. Liapounov and O. Struve, on the great nebula of *Orion*.

Nouvelle Determination de la Parallaxe Annuelle des Etoiles α Lyræ et 61 *Cygni.* Par M. O. Struve, Mém. de l'Acad. de St. Pet. VII. Serie, t. i. No. 1.

The observations upon which these determinations are founded were made at the Pulkova Observatory in the years 1851–52, and an abstract of the memoir is published in the *Bulletins* of the Academy, t. xiii. (1855), p. 283, so that the results of the investigation have been for some years in the possession of astronomers. See also *Monthly Notices*, vol. xiii. p. 74, and vol. xiv. p. 159.

Pulkowaer Beobachtungen des Grossen Cometen von 1858. Erste Abtheilung, Beobachtungen am Refractor angestellt von O. Struve. Zweite Abtheilung, Beobachtungen am Heliometer nebst Untersuchungen ueber die Natur des Cometen von Dr. A. Winnecke. Mit sechs Tafeln. Gelesen am 29 Ap. 1859. Mém. de l'Acad. de St. Pet. VII. Serie, t. ii. No. 1 (1859).

The comet was first seen at Pulkova on the 16th August in the refractor, and with the naked eye on the 19th August; but, on account of the smoke from the burning of the morasses, no observations could be taken in that month; and the observations of position and configuration recorded in the memoir extend from the 2d Sept. to the 13th Oct. 1858. There are several elaborate drawings of the comet.

Librorum in Bibliotheca Speculæ Pulcovicensis Anno 1858 *exeunte contentorum Catalogus Systematicus:* Edendum curavit et præfatus est Otto Struve. Petropoli, 1860.

The Library of the Pulkova Observatory, in the year 1845, when the former Catalogue was published, comprised

2068 works, contained in 4150 volumes,
60 celestial charts, and
3109 memoirs and smaller works.

The present catalogue to the end of the year 1858 shows

4113 titles of works, contained in 7625 volumes,
143 celestial charts, and
14,634 titles of memoirs and smaller works;

but the titles of a large proportion of the memoirs are taken from Transactions of Societies and other collective works.

The Catalogue is divided into two parts; the former of

them (pp. 1–262 and 819–830) comprising the separate works (*libri majores*), and the latter (pp. 265–818 and 831–857) the memoirs, &c. (*libri minores et dissertationes*), and in each part the arrangement is a classified one, according to subjects; there being also to each of them an alphabetical index of authors' names. It might, perhaps, have been preferable to blend together these two indices. The arrangement is a most admirable one; and not only with respect to astronomy, but even as regards pure mathematics, the catalogue will be most valuable as a work of reference. If it were not that the work itself ought to be in the hands of all concerned, it would be worth while to exhibit the divisions and subdivisions of the subjects, as shown by the contents or *Systema Catalogi* (pp. xxv.–xxx.) of the introduction.

Anseinandersetzung einer zweckmässigen Methode zur Berechnung der absoluten Störungen der kleinen Planeten. Von P. A. Hansen (Abhandlungen der k. Sächs. Gesell. zu Leipsig. Erste Abh. t. v. pp. 44–218, 1856; Zweite Abh. t. vi. pp. 3–148, 1857; Dritte Abh. t. vii. pp. 83–335, 1859).

Only a short account can be given of these elaborate and important memoirs. The method is, in its general character, similar to M. Hansen's method in the lunar theory, viz. it is assumed that the longitude in orbit (departure) and the radius vector are functions, the former of the same form and the latter of the same form (except that the expression contains a variable factor which has to be determined) as in the elliptic theory, but instead of the mean anomaly there is a function z of the form $n\,t +$ periodic and secular terms, the expression for which has to be determined by the theory. The perturbations of the plane of the orbit are taken account of in a very elegant manner. The development of the disturbing function is effected in terms of the eccentric anomalies of the two planets: it is stated that a greater convergency of the series is thereby obtained. The values of the coefficients are found by the method of quadratures. The method is applied to the calculation of the perturbations of *Egeria*. The perturbations depending on the first powers of the masses of *Jupiter*, *Saturn*, and *Mars*, are obtained in the second memoir; those depending on the powers and products of the second order (viz. $(Jupiter)^2$ and *Jupiter* × *Saturn*, which are considered as the only sensible cases) are obtained in the third and concluding memoir, which, as the author remarks, affords the first instance of the calculation of the perturbations of the second order for one of the small planets.

On the Secular Variations and Mutual Relations of the Orbits of the Asteroids. By Simon Newcomb. (Memoirs of the American Academy, New Series, t. v. pp. 123–135, Communicated 24th April, 1860.)

The following is an outline of this interesting memoir. The object is stated to be the examination of those circumstances of the forms, positions, variations, and general relations of the asteroid orbits, which may serve as a test, complete or imperfect, of any hypotheses which may be made respecting the cause from which they originated, or the reason why they are a group by themselves. Every *à priori* test is founded on the supposition that the hypothesis to be tested necessarily or probably implies that certain conditions must be fulfilled by the asteroids or their orbits. The tests consist in observing whether these conditions are fulfilled. The conditions may be divided into two general classes,—those which are rigorous and necessary, and those which are merely probable. The nature of the latter conditions appears from the examples which are subsequently given of their deduction from hypotheses.

Two hypotheses worthy of consideration have been promulgated respecting the origin of the asteroids: one (Olbers' hypothesis), that they are the fragments of a single planet, shattered by some unknown cause; the other, that they were formed by the breaking up of a revolving ring of nebulous matter.

To apply rigorous tests to either of these hypotheses it is necessary to have rigorous expressions in terms of the time, for the values of the excentricity, inclination, longitude of perihelion, and longitude of node of each asteroid used in applying the test. For the probable tests it is necessary to have the mean and the limiting values of the same elements; and to obtain these the same expressions are required.

The subject is arranged under the following heads:—

§ 1. Computation of the rigorous expressions in terms of the time, of the elements of the asteroids.

§ 2. On the possibility that the orbits of all the asteroids once intersected in a common point.

§ 3. Have the elements of the asteroid orbits ever been materially affected by a resisting medium?

§ 4. Of the relations among the mean distances, excentricities, and inclinations of the orbits of the asteroids; and between their masses and the velocities with which they must have been projected, if Olbers' hypothesis be true?

§ 5. Of certain observed relations among the asteroids which are the necessary or probable result of known causes, and, therefore, throw no light on the origin of the asteroids.

The investigations of § 1 are the mathematical basis of the memoir. The secular variations h, l ($= e \sin \varpi$, $e \cos \varpi$), and p, q ($= i \sin \Omega$, $i \cos \Omega$), of an asteroid, are to be deduced from the expressions given in the *Mécanique Céleste*, liv. ii. § 55 and 59. In these expressions h, l, are determined by linear differential equations, which involve (besides l, h) the corresponding quantities l', h', l'', h'', &c. for the disturbing planets, and in like manner p, q, are determined by linear differential equations, which involve (besides q, p) the corresponding quantities q', p', q'', p'', &c. for the disturbing planets. But the actions of the asteroids on each other, and on the larger planets, are neglected; l', h', p', q', &c. relate, therefore, to the larger planets, and are considered as known functions of the time,—the numerical values for the planets considered are taken from t. ii. of the *Annales de l'Observatoire de Paris*. The remaining quantities in the equations depend on the mean distance of the asteroid, and they are tabulated in the memoir for every ·05 in the value of the mean distance, between the limits 2·20 and 3·20, of the asteroids. The data are then applied to the asteroids the elements of which are determined with sufficient accuracy, and the excentricities and inclinations of which are sufficiently small; the latter class being presumed to include all those for which each of these elements is less than 11°; and in this manner expressions for h, l, p, q, in terms of the time, are obtained (pp. 133–137) for the asteroid,—*Ceres, Vesta, Astræa, Flora, Metis, Hygeia, Parthenope, Irene, Psyche, Thetis, Fortuna, Massilia, Lutetia, Themis, Proserpina, Euterpe, Bellona, Amphitrite, Urania, Pomona, Circe, Fides, Leda, Lætitia, Harmonia.*

From these expressions are deduced the following conclusions:—

1. *Harmonia* is the only asteroid among those the elements of which are well determined, the orbit of which can ever approach indefinitely near the circular form. *Doris* may possibly be found to be an additional asteroid in this class.

2. *Euterpe* is the only known asteroid the orbit of which can ever approach indefinitely near the invariable plane of the planetary system.

3. The perihelion of each asteroid (*Harmonia, Doris,* and *Euterpe,* only excepted) revolves nearly in the same time as its node, the time of revolution varying from about 15,000 to 40,000 years.

4. The excentricities and inclinations to the invariable plane, of the asteroids considered, cannot exceed the values given in the memoir for the same asteroids respectively.

§ 2. If Olbers' hypothesis be true the orbits must once have had a common point of intersection.

It appears that under the assumption of the investigation the orbit of *Hygeia* could never have intersected with that of *Vesta, Flora, Metis, Urania,* or *Harmonia;* and that the orbit

of *Psyche* could never have intersected with that of *Flora* or *Urania*. But as two asteroids might, by their mutual attraction if they came sufficiently near, change each other's mean distance very materially, the result cannot be considered as conclusive against the hypothesis, and it does not seem possible absolutely to disprove the hypothesis by an attempt at rigorous computations of the secular variations of the asteroids.

§ 3. The conclusion arrived at is that, if the motions of the asteroids are affected by a resisting medium, the former positions of some of the orbits were more unfavourable for a common point of intersection than their present ones.

§ 4. On all probable hypotheses on the cause of an explosion of a planet—the smaller fragments ought on the whole to be thrown off with a greater velocity than the larger ones. Moreover, when (as in the case of the asteroids) each fragment is small compared with the original mass, it seems at least highly probable that the velocities of those thrown off in any one direction would be very nearly the same on the whole as the velocities of those thrown off in a direction at right angles to that of the former one. There are thus two probable tests of Olbers' hypothesis. It appears that there is a remarkable agreement of the circumstances of the asteroids with the second test, and this favours Olbers' hypothesis, but no such relation exists as is supposed by the first test.

§ 5. The conclusion appears to be that certain peculiarities which have been observed as to the distribution of the perihelia and nodes of the asteroids, and other observed relations, do not furnish any argument for or against Olbers' hypothesis. But it has been suggested that the inclinations are usually small, because the asteroids are looked for near the plane of the ecliptic, and (this being so) it seems probable that the mean inclination of the whole number of the asteroids, known and unknown, is much greater than that of the known asteroids; and according to the author the fact, if so, furnishes an additional argument against the hypothesis of explosion.

Brünnow's Spherical Astronomy; translated by the Rev. R. Main. Part I., including the chapters on Parallax, Refraction, Aberration, Precession, and Nutation. Cambridge, 1860.

The excellence of the original work is well known; the translator remarks that the want of a text-book for Spherical Astronomy has been long felt at Cambridge and in the other universities of the British Isles in which the mathematical sciences are cultivated. And he hopes that the translation,

although incomplete, may be of considerable service, since, with the exception of the detailed accounts, given in the latter portion of the original work, of the construction and use of instruments and of the methods employed by modern astronomers for deducing from observations the most accurate values of the constants employed in Astronomy, the portion printed contains nearly the whole which would be valuable to English students; in particular, the theories of Parallax, Refraction, Aberration, Precession, and Nutation, are given in a more complete form than is to be found in any English work.

Tables for facilitating the Reduction of Lunar Observations. By C. F. A. Shadwell, Esq., C.B., Captain R.N., London, 1860.

The formulæ from which the lunar tables are derived were originally proposed by the late Lieut. Henry Raper, R.N., in the 18th volume of the *Monthly Notices*. The author remarks, "Rigorous, elegant, and concise, Raper's formula can scarcely fail to recommend itself to the notice of the scientific student—while the brevity and simplicity of the tables necessary for its practical application give the method of reduction derived from it great claims to the attention of the practical navigator."

The work is divided in two chapters; the first contains the theory of the method; the second, practical rules, with examples, illustrating their application. The tables are comprised in the concluding pages, 54–63, of the work. In Chapter I. the opportunity is taken to explain, and in some measure to criticise, the various rules and tables for solving the problem, depending on Lyons' formula, which have been published from time to time by various authors. It is remarked that Lyons' formula ranks high among the approximate methods which have been devised for solving the lunar problem; Raper's formula, however, while equally brief and quite as easy in numerical solution, has the advantage of affording a rigorous mathematical result; and that, while equally available at sea with other methods, it is therefore peculiarly suited for the reduction of lunar observations on shore, where extreme precision is required. It may be anticipated that the work will, as the author hopes, prove acceptable to practical navigators and scientific travellers, and be received as a useful contribution to nautical astronomy.

In the *Bulletins* of the 6th, 7th, and 8th Dec. 1860, M. Le Verrier gives an account of his "Théorie et Tables du Mouvement de *Venus*." The work is divided into five sections.

Section 1 is devoted to the perturbations of *Venus* by *Mercury*, the Earth, *Mars, Jupiter*, &c. All the terms which rise to the half-hundredth of a second are scrupulously taken account of. The long inequality depending on 13 times the mean motion of the Earth less 8 times the mean motion of *Venus*, the discovery whereof is due to Mr. Airy, has been determined anew, the approximation being carried to the terms of the seventh order as regards the excentricities and the inclinations. Among the terms depending on the second power of the disturbing force, that depending on 4 times the mean motion of *Mars* less 3 times the mean motion of *Venus* less 7 times the mean motion of the Earth, is sensible, as in the theory of the motion of the Earth. It has been determined with care. The formulæ for the secular inequalities of *Venus* show that the action of *Mercury*, taking the mass at $\frac{1}{3000000}$ of the mass of the Sun, amounts to two-thirds of the action of the Earth; it is thus very sensible, and the observations of *Venus* during the last century ought to conduct to a reliable determination of the mass, still so imperfectly known, of *Mercury*.

Section 2 contains the establishment of all the formulæ necessary in the theory of *Venus*.

In Section 3 are collected all the observations of *Venus* which are made use of. The more ancient observations are of no service; the available ones are:—1, a series of meridian observations from Bradley in 1750 to the present time; 2, observations of the transits of 1761 and 1769, and, to a certain extent, the transit of 1639; 3, a remarkable observation of an occultation of *Mercury* by *Venus*, made at Greenwich in the year 1737, and which some circumstances render very precious. The "Reduction of the Greenwich Observations of Planets from 1750 to 1830" has been largely made use of; and as the positions of the stars employed in the reductions are there given, M. Le Verrier has been able to introduce the modifications arising from his own discussion of Bradley's star-observations. As the precision of observation of the occultation of *Mercury* by *Venus* was unknown, this observation was not used in the determination of the elements of the tables, but it afforded a verification of the tables.

Section 4 contains the results of the comparison of the theory with the observations.

The recent observations give the elements of the motion of the planet at the present time; and the ancient ones, which give the mean motion, are also the only ones which can lead to the values of the disturbing masses of *Mercury* and the Earth. Taking the mean motion of the planet from the observations of the transits of 1761 and 1769, the mass of *Mercury* can only be deduced from the longitudes given by Bradley's meridian ob-

servations. And these lead to sufficiently precise results, from which it appears that the mass of *Mercury* should be reduced to about $\frac{1}{5000000}$ of the mass of the Sun, which agrees with the result obtained by M. Encke from his comet of short period.

The mass of the Earth is obtained chiefly from the observations of the latitude. The aggregate of the observations of the transits of 1761 and 1769 give a first equation, and a second one is deduced from the aggregate of Bradley's observations of the latitudes. These two equations agree in showing that the received mass of the Earth must be augmented by about *one-tenth* of its value—the lunar equation in the theory of the motion of the Earth had already shown that the mass of the Earth required to be considerably augmented.

Section 5 comprises the tables, xxxviii. in number, necessary for the calculation of the places of the planet. The tables satisfy all the known observations. They represent very well the aggregate of the meridian observations, and satisfy the observations of the transits, including that of 1639 in the limits of its accuracy. It appears, also, that using them concurrently with M. Le Verrier's tables of *Mercury* and of the Sun, to calculate the occultation of *Mercury* by *Venus* in 1737, the agreement affords a remarkable confirmation of the accuracy of the tables of the Sun, of *Mercury*, and of *Venus*.

The theory of *Venus*, based on the reciprocal action of the sun and the planets, presents no anomaly. The theory of Universal Gravitation, applied to known physical causes, gives a perfect account of the motion of the Earth and of *Venus*; more than this, it does the same with respect to *Mercury*, except as to a single point, the secular variation of the perihelion; and it is impossible to doubt (M. Le Verrier concludes) but that the ring of small planets interior to the orbit of *Mercury*, the consideration whereof is indispensable to remove this discrepancy, has a real existence.

Note sur les Inégalités Lunaires à longues Périodes dues à l'action perturbatrice de Vénus. Par M. Delaunay. (Extract.)

(*Communicated by the Astronomer Royal.*)

La discussion des observations de la Lune ayant amené les astronomes à admettre dans son mouvement l'existence d'une ou de plusieurs inégalités à longue période, on a cherché à en trouver la cause dans les actions perturbatrices auxquelles cet astre est soumis. C'est ainsi que M. Hansen a trouvé que l'action

de *Vénus* introduit dans la valeur de la longitude de la lune les deux inégalités suivantes:

$$+ 27''\cdot 4 \sin (- l - 16\, l' + 18\, l'' + 35^\circ\, 20'\cdot 2)$$

(période de 273 années)

$$+ 23''\cdot 2 \sin (8\, l'' - 13\, l' + 315^\circ\, 20'),$$

(période de 239 années).

l, l', l'', étant respectivement les anomalies moyennes de la Lune, de la Terre, et de *Vénus*. La première de ces deux inégalités est produite par l'attraction directe de *Vénus* sur la Lune; en ne tenant compte que de la première puissance de cette action perturbatrice, M. Hansen avait trouvé $16''\cdot 01$ pour son coefficient: c'est en poussant l'approximation jusqu'aux quantités de l'ordre du produit du cube de la force perturbatrice du soleil par la masse de *Vénus* qu'il a dû porter ce coefficient de $16''\cdot 01$ à $27''\cdot 4$. La seconde inégalité dépend en partie de l'attraction directe de *Vénus* sur la Lune, et en partie de cette attraction réfléchie par l'intermédiaire de la Terre; son argument est celui pour lequel M. Airy a montré le premier qu'il a un coefficient sensible dans le mouvement de la Terre. Ces résultats obtenus par M. Hansen ont été communiqués par lui à l'Académie des Sciences de Paris dans sa séance du 5 Mai, 1847; il annonçait en même temps qu'il se proposait de refaire le calcul des deux inégalités qu'il avait trouvées, parceque leurs coefficients ne lui paroissaient pas déterminés avec toute l'exactitude désirable.

M. Hansen revient sur ces inégalités à longues périodes produites par *Vénus*, dans une lettre adressé à M. Airy, au sujet de la construction de ses Tables de la Lune, et insérée dans les *Monthly Notices* (Novembre 1854). Voici ce qu'on y lit à l'occasion de la différence entre la valeur qu'il adopte pour le moyen mouvement de la Lune et celle que M. Airy avait précédemment obtenue: " . . . . This arises from the circumstance that I have slightly altered the coefficients of the two inequalities of long period. The accurate determination of these two inequalities by theory is the most difficult matter which presents itself in the theory of the moon's motion. I have on two occasions, and by different methods, sought to determine their values, but I have obtained results essentially different from each other." On trouve, en effet, dans le préambule des Tables de la Lune de M. Hansen, que les deux inégalités dont il est question y ont été introduites avec les valeurs suivantes:—

$$+ 15''\cdot 34 \sin (- l - 16\, \mathrm{E} + 18\, \mathrm{V} + 30^\circ\, 12')$$

$$+ 21''\cdot 47 \sin (8\, \mathrm{V} - 13\, \mathrm{E} + 274^\circ\, 14').$$

V designant la longitude moyenne héliocentrique et sidérale de

Vénus, E celle de la Terre, et l l'anomalie moyenne de la Lune. Les coefficients qui, comme on le voit, diffèrent notablement de ceux que M. Hansen leur avait d'abord attribués, et que nous avons rapportés plus haut, paraissent avoir été choisis de manière à satisfaire convenablement aux observations tant anciennes que modernes, et présentent ainsi un caractère purement empirique.

Ce point de la théorie de la Lune a dû naturellement attirer mon attention, en raison de l'incertitude qui en résulte sur la réalité de l'existence des deux inégalités trouvées par M. Hansen, ou au moins sur la grandeur de leurs coefficients. Je me suis donc occupé d'en effectuer moi-même la détermination, en profitant de mes recherches antérieures sur le mouvement de la Lune. L'objet de cette note est de faire connaître les résultats aux quels je suis parvenu.

Relativement à la première des deux inégalités de M. Hansen, les calculs aux quels je me suis livré m'ont conduit à une confirmation partielle de ses résultats. En m'en tenant d'abord à la première puissance de l'action perturbatrice de *Vénus* sur la Lune, j'ai trouvé pour cette inégalité

$$+ 16''{\cdot}024 \sin(-l - 16\,l' + 18\,l'' + 35^\circ\,20'{\cdot}2),$$

valeur identique avec celle que M. Hansen avait obtenue dans le même cas. Mais ensuite, en poussant les approximations plus loin, c'est à dire en allant jusqu'aux quantités de l'ordre du produit de la masse de *Vénus* par le cube de la force perturbatrice du soleil dans les termes indépendents de l'inclinaison de l'orbite de *Vénus* sur l'écliptique, et jusqu'aux quantités de l'ordre du produit de la masse de *Vénus* par la cinquième puissance de la force perturbatrice du soleil dans les termes qui dépendent de cette inclinaison, je n'ai obtenu qu'une très-légère modification à mon premier résultat: j'ai trouvé pour l'inégalité

$$+ 16''{\cdot}336 \sin(-l - 16\,l' + 18\,l'' + 35^\circ\,16'{\cdot}5).$$

Ainsi les approximations ultérieures n'ont fait qu'augmenter son coefficient de $0''{\cdot}312$. La détermination numérique de cette inégalité a été faite en adoptant, comme M. Hansen, $\frac{1}{408134}$ pour le rapport de la masse de *Vénus* à celle du soleil. Si l'on prenait pour ce rapport la valeur plus grande $\frac{1}{400000}$ qui parait mieux s'accorder avec les perturbations produites par *Vénus*, le coefficient de l'inégalité dont nous nous occupons devrait être porté de $16''{\cdot}336$ à $16''{\cdot}668$.

Le résultat auquel je suis arrivé pour la seconde des inégalités de M. Hansen est tout différent: au lieu des coefficients $23''{\cdot}2$ et $21''{\cdot}47$ qui M. Hansen lui a attribués successivement, j'ai trouvé que son coefficient est à peu près nul. Suivant lui, cette inégalité est due en partie à l'attraction directe de *Vénus*

sur la Lune, et en partie à cette attraction réfléchie par l'intermédiaire de la Terre. J'en ai effectué la détermination en tenant compte de ce double mode d'action de la planète troublante. La partie de cette inégalité qui provient de l'attraction de *Vénus* réfléchie par l'intermédiaire de la Terre, résulte de l'existence de l'inégalité de même argument trouvée par M. Airy dans le mouvement de la Terre autour du soleil; j'ai pu facilement m'assurer qu'elle ne s'élève pas à $\frac{1}{3}$ de seconde. Quant à la partie de l'inégalité en question qui est due à l'action directe de *Vénus* sur la Lune, j'en ai fait le calcul en poussant les approximations assez loin pour ne pas craindre d'obtenir un résultat inexact, et j'ai reconnu qu'elle est absolument insensible.

D'après ce qui précède, la première des deux inégalités lunaires à longues périodes dues à l'action perturbatrice de *Vénus* doit seule être prise en considération dans les Tables; et son coefficient, qui je trouve égal à $16''\cdot668$, diffère peu de celui ($15''\cdot34$) auquel M. Hansen s'est arrêté pour satisfaire convenablement aux observations.

Le mémoire dans lequel j'ai développé en détail les calculs relatifs à la première inégalité, a été imprimé dans les *Additions à la Connaissance des Temps pour* 1862. Un second mémoire, contenant tous les détails du calcul de la seconde inégalité, paraîtra incessamment.

Note by the Astronomer Royal.

As several allusions have lately been made to the degree of empiricism in Professor Hansen's determination of the coefficients of the two long inequalities of the moon produced by the disturbing force of *Venus*, to which Professor Hansen has adverted in his letter of 1854, Nov. 3 (of which letter a translation is printed in the *Monthly Notices* of 1854, Nov. 10), I think it desirable to give the original of the most important sentence, and to annex what appears to be a correct translation.

The original is —

"In meinen Mondtafeln habe ich einstweilen Coefficienten angewandt, die nicht frei von einigen Empirismus sind."

The correct translation appears to be —

"In my Lunar Tables I have provisionally applied coefficients which are not free from some empiricism."

Royal Observatory, Greenwich,
1860, *December* 28.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI. *January* 11, 1861. No. 3.

The Rev. R. MAIN, President, in the Chair.

J. Stuart Stuart Glennie, Esq., 6 Stone Buildings, Lincoln's Inn;
Henry George Bohn, Esq., York Street, Covent Garden;
Philip E. Sewell, Esq., Fuente del Mar, Santander;
John M. Stothard, M.D., 11 Lower Sherrard Street, Dublin;
E. J. Stone, Esq., First Assistant, Royal Observatory, Greenwich; and
C. P. Mason, Esq., Denmark Hill Grammar School,

were balloted for and duly elected Fellows of the Society.

On the Binary Star η Cassiopeæ.
By Eyre B. Powell, Esq.

I believe up to this time no orbit has been put forward for the binary star, η *Cassiopeæ;* I am aware of attempts having been made in past years to arrive at elements by two or three individuals beside myself, but the results proved altogether unsatisfactory, owing to the irregularities existing among the early observations, especially those of distance. I now do myself the pleasure of laying before the Society an approximate orbit, at which I have arrived after the expenditure of no little trouble; but, in so doing, I wish it to be understood that, in consequence of the peculiar circumstances of the case, I do not claim for the elements any higher rank than that of a *first* approximation to the truth.

Some of the early distance measures are utterly irreconcilable with one another; and, perhaps, the most important, that of the founder of this branch of astronomy, Sir William

Herschel, is shown to be considerably too small by Kepler's law of areas. The angle of true anomaly, moreover, which has been described since 1779, falls short of 40°, and is so situated as not to afford a good grasp of the orbit. Any conclusions, therefore, which may be drawn at present must necessarily be insecure. Still, as it will take some thirty-five years for the *comes* to round the vertex of the apparent ellipse and reach its periastre, before which time a close approximation to the elements will scarcely be attainable, there seems no reason for deferring the attempt to reduce the motion in some degree to line and measure.

After some previous approximations I arrived at the following elements, using for the most part Sir John Herschel's graphical method, and calculating n and τ by means of different pairs of equations, the final sets of which afforded results in fair agreement with each other. Here I may remark in passing that this way of determining the mean motion and the time of periastral passage seems to me decidedly the best, when once the perspective ellipse has been fixed with tolerable accuracy.

Apparent Orbit.

Axis major	$= 15''\cdot8$
Axis minor	$= 9''\cdot2$
Maximum distance	$= 12''\cdot84$
Position angle for do.	$= 60°$
Minimum distance	$= 1''\cdot3$
Position angle for do.	$= 288° \; 10'$
C A, projection of semi-major axis of real orbit	$= 6''\cdot72$
C B, projection of semi-minor axis of real orbit	$= 6''\cdot1$
C S, projection of linear excentricity of real orbit	$= 5''\cdot18$
Position angle for S A	$= 252° \; 30'$
Position angle for focal distance parallel to C B	$= 190° \; 50'$

Elements of Real Orbit.

$$\varpi = 252° \; 30'$$
$$e = \cdot770833$$
$$\Omega = 25° \; 33'$$
$$\gamma = 57° \; 59'$$
$$a = 10''\cdot335$$
$$n = 1°\cdot989, \quad P = 181 \text{ years nearly,}$$
$$\tau = 1715\cdot0$$

The annexed table exhibits the degree of correctness with which the elements represent the recorded motion of the star; in it I have taken the most reliable of the observations within my reach, and in many cases have used the means of nearly contemporaneous groups.

Date.	P_0	$P_c—P_0$	D_0	$D_c—D_0$	Observer.	Remarks.
	° ′	′	″	″		
1779·63	62 4	− 96	11·27	+ 1·43	H	P_0 = 60° 6′ for 1782·4, according to h, in vol. v., R. Ast. Soc. *Memoirs.* The value here is from the *Phil. Trans.*
1803·1	70 46	+ 32	......	......	H	
1819·8	80 12	+ 10	10·8	+ ·13	Σ	
1825·78	83 5	+ 61	9·9	+ ·54	S	
1830·17	87 13	− 6	10·1	− ·04	h, Sm	h., 1829·43; Sm., 1830·91.
1833·3	89 1	+ 24	9·91	− ·14	Sm, D, Sm, Sm.	Sm., 1831·84; D., 1832·87; Sm., 1833·7; Sm., 1834·77.
1836·79	92 0	+ 6	9·43	+ ·01	Σ, Sm	Σ. and Sm. in admirable agreement. Σ., 1836·78; Sm 1836·81.
1843·19	95 48	+ 109	9·1	− ·28	Sm	On examining the interpolating position curve, P_0 is clearly seen to be too small.
1847·42	102 0	+ 47	8·65	− ·36	J	
1851·84	106 38	− 7	8·06	− ·07	J, J, J	1850·876; 1851·89; 1852·76.
1853·68	109 23	− 42	7·95	− ·21	J, J, P	J., 1853·14; P., 1853·92; J., 1853·99.
1856·0	112 26	− 56	7·6	− ·06	J, P	J., 1856·07; P., 1855·93.
1857·56	114 2	− 30	7·45	− ·11	J, J	1857·06; 1858·06.
1859·72	116 35	− 5	7·02	+ 1·1	P	

H, Sir W. Herschel; Σ, Professor Struve; S, Sir J. South; h, Sir J. Herschel; Sm, Admiral Smyth; J, Captain Jacob; P, myself.

Owing to the unfavourable weather here, I have not secured any recent observations of η.

For the purpose of comparing the orbit with future observations I append the calculated places of the *comes* for the next five years.

Date.	Position.	Distance.
	° ′	″
1861·0	118 21	6·99
1862·0	119 51	6·89
1863·0	121 21	6·79
1864·0	122 58	6·69
1865·0	124 35	6·59

It is to be remarked, however, that the arc which will be described during the next ten or twelve years may be made, within moderate limits of error, to belong to different ellipses partaking of an osculating character.

Madras, December 1, 1860.

On the Three New Variable Stars, T *Bootis,* T *Serpentis, and* S *Delphini.* By Joseph Baxendell, Esq.

1. The first of these variables precedes *Arcturus* $1^m 45^s$, and is 11′ 30″ more south. It was mapped down as a $9\frac{3}{4}$ magnitude star on the 9th of April last, and on the 11th it was again seen and estimated to be of the 10th magnitude; but on the 22d it had diminished to the 12·8 magnitude, and on the following night it was invisible with Mr. Worthington's 13-inch reflector, in a sky which permitted stars of the 14th magnitude to be seen. It has frequently been looked for since, but not seen.

2. On the 12th of July last, while comparing with the heavens a chart of the cluster No. 72 of Sir W. Herschel's 8th class, I observed a star of the 11th magnitude in a position in which none was laid down on the chart, and on referring to the notes appended to my measures of the positions of the neighbouring stars I satisfied myself that this star was not visible, or, at all events, not brighter than the 13th magnitude in July and August 1859, when the chart was constructed. It had a deep yellowish red colour, which alone would have drawn attention to it had it been visible during my previous examinations of the cluster. For several days its brightness appeared to remain unchanged, but afterwards it diminished very gradually, and on the 13th of September it was no longer visible with Mr. Worthington's large reflector, and was therefore below the 14th magnitude. From the course of its curve of variation it appears probable that it had already passed a maximum when first seen on the 12th of July. Its place for 1860 is $18^h 21^m 59^s$, $+6° 12'{\cdot}7$.

3. The third variable is No. 4351 Zone +16° of the *Bonn Catalogue*, its place for 1855 being $20^h 36^m 24^s{\cdot}1$, $+16° 34'{\cdot}2$. On the 25th of September, 1860, I was surprised to find it a full magnitude brighter than I had ever before seen it, being equal to its neighbour, No. 4350, of the 8·3 magnitude, the two thus forming a fine but wide double star. From the 28th of September to the 8th of October it was thought to be slightly brighter than 4350, but in the beginning of November it had become sensibly less bright, and on the 18th of December it had diminished to the 11th magnitude, at which it has since remained. It was observed as a 9th magnitude star by Bessel on October 7, 1823, in Zone 192. In the *Bonn Catalogue* its magnitude is 9·5.

Manchester, Jan. 9, 1861.

Results of Meridional Observations of Small Planets; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of December, 1860.

(Communicated by the Astronomer Royal.)

Flora (8).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Dec. 17	9 22 51·80	3 9 44·21	80 5 25·11
18	9 18 40·06	3 9 28·35	79 59 54·44

Psyche (16).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Dec. 17	10 0 43·07	3 47 41·70	74 44 34·47
18	9 56 11·64	3 47 6·10	74 45 11·46

Massilia (20).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Dec. 18	12 12 0·46	6 3 17·23	67 42 9·87
19	12 7 0·67	6 2 13·18	67 42 19·03
22	11 52 0·94	5 59 0·66	67 42 52·47

Euterpe (27).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Dec. 5	7 34 20·41	0 33 36·30	88 29 48·58
6	7 30 54·23	0 34 6·12	88 25 15·89

Amphitrite (29).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Dec. 8	9 31 44·57	2 43 9·42	65 1 52·08
18	8 48 22·98	2 39 6·30	65 33 46·62

No occultations of stars by the moon were observed during the month of December 1860.

Occultations and Transits of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1860.			h m s	
Dec. 18	I.	Tr. egress	12 2 23·86	E.
18	IV.	Occ. disapp. first cont.	12 18 21·26	E.
18	IV.	,, central bis.	12 21 20·76	E.
18	IV.	,, last cont.	12 23 20·44	E.
18	IV.	Occ. reapp. first cont.	17 9 28·47	A. D.
18	IV.	,, central bis.	17 12 3·03	A. D.
18	IV.	,, last cont.	17 14 17·67	A. D.

The initials E. and A. D. are those of Mr. Ellis and Mr. Davis.

On the Lunar Theory. By Sir J. W. Lubbock, Bart.*
(Abstract.)

The memoir is chiefly occupied with the comparison and discussion of the numerical values of the coefficients of the several inequalities, as given by M. Plana and M. de Pontécoulant, and in the *American Tables*, Washington, 1853. It is shown what are the quantities which should be added to the longitudes and latitudes of the *American Tables* in order to obtain those which would be given by the coefficients of Pontécoulant, when quantities under $0''\cdot 3$ are neglected; these corrections are so small that, practically, the places given by the *American Tables* may be considered as identical with the places which would be given by tables founded upon Pontécoulant's coefficients, and therefore by the theory of Lubbock and Pontécoulant. The author remarks:—"There is no error in M. Plana's analytical expression for the longitude in terms of the first, second, third, or fourth order. There are three errors of the fifth order, of which one is insensible. In M. Plana's analytical expression for the latitude there are no errors of the first, second, or third order, and only two of the fourth order. By carefully examining M. Plana's numerical reductions, M. de Pontécoulant and myself have succeeded in discovering the causes of the principal differences between M. Plana's coefficients and those of M. de Pontécoulant: there remain discrepancies in terms of the fifth and higher orders which it is very desirable should be got rid of. M. de Pontécoulant and myself, where we differ from M. Plana, went over our calculations so many times that we think the error can hardly be on our side; and unless M. Plana will revise

* The Memoir, which was read at the Meeting in November last, will probably appear *in extenso* in the *Memoirs* of the Society.—Ed.

his work, we must despair of this being ever accomplished: for no one again will ever possess the intimate knowledge which M. Plana has of the indirect method. As it appeared to me that astronomers would view with greater confidence a comparison of places given by the *American Tables* madè by persons who could have no interest in enhancing their value, I made application to Mr. Hind, the Superintendent of the *Nautical Almanac;* and, in consequence, he directed Mr. Farley to procure places of the Moon from the *American Almanac*, and compare them with the observations made at Greenwich for the years 1856, 1857, and 1858; and as Mr. Hind has kindly allowed me to publish them with this paper, any one can see at once how extremely accurate the places given by these tables are, and how much more so than those given by Burckhardt's Tables. In these *American Tables* coefficients are employed, with very few exceptions, and those of no moment, founded on our labours—that is, M. Plana's, M. de Pontécoulant's, and my own—and due to theory alone. I am confident, therefore, that a joint posterity will give to us—that is, to Plana, Pontécoulant, and Lubbock, who, in 1846, furnished the means of constructing tables of the moon without any empirical hypotheses—the credit of first bringing the errors of the lunar theory within the errors of observation, and thereby bringing to perfection the solution of the problem of finding the longitude at sea by means of lunar observations."

The memoir contains an investigation, by means of the equations employed in the author's lunar theory (that is, in which the time is the independent variable), which sustains Prof. Adams' value of the second term $\left(= \frac{3771}{64} m^4 e'^2\right)$ in the expression for the acceleration. It contains also two examples of the determination of the inequalities of the reciprocal of the radius vector and the longitude.

The President gave a short account to the Meeting of the proceedings at the Radcliffe Observatory since the decease of the late M. J. Johnson, and his own appointment as Radcliffe Observer. Observations were made regularly with both the Meridian Instruments. The photographic registration of meteorological observations had been carried on without any interruption, and with great regularity. Several amendments which were required in the Heliometer had been successfully effected, and the instrument was then in good working order.

On Controlling Clocks by Electricity.
By Charles V. Walker, Esq.

Mr. Charles V. Walker gave a verbal address, which he has since, at the request of the Editor, kindly reduced into writing, as follows:—

"Mr. President,—You are fully aware—no one more so—that the clocks (certain of them, at least) on the South-Eastern Railway should exhibit very correct time. Over and above their ordinary duty as timekeepers, some of them have special service to perform in behalf of the Royal Observatory, with all of which you are personally very familiar, but which it may be interesting to explain to the Fellows of this Society, in so far as a certain clock in the Telegraph Office of the London Bridge Station is concerned, and which clock is under the immediate control of the prime clock in the Royal Observatory, on which error is not allowed to accumulate. I will first explain the special service required of this clock, and then describe the arrangements by which it is retained under the control of the distant clock in question, and made to show the same time, second by second.

"For the last ten years a very elaborate system of automatic distribution of time-signals, including the daily drop of a time-ball at Deal, has been in operation on the South-Eastern Railway. As far as I have been concerned, it originated in a conversation between myself and Mr. Glaisher on April 13, 1849, followed by a letter from him on May 10, in which he said, 'I also wish to talk with you about the laying down a wire from the Observatory to the Lewisham Station.' The question was taken up with great zeal and activity by the Astronomer Royal, and ere long the necessary agreements between the Admiralty and the Railway Company were executed. The Company very readily fell into our views, and erected four wires between Lewisham Station and London Bridge, charging for them merely the cost price; they charge the Observatory a few shillings annually for maintenance, and a few shillings for rent and right of way—the sums being merely nominal. The Observatory supply the Railway Company with a time-signal every hour, if required, and with other signals every second or two seconds, as necessities may dictate, for driving or controlling clocks. The Royal Observatory and Lewisham Station were connected by four gutta-percha wires, laid under Greenwich Park and across Blackheath. In course of time the buried wires became defective, and, to take their place, wires were suspended in the air, in 1860, from the Observatory to Greenwich Railway Station; and the railway wires were, at the same time, transferred from the North Kent Railway, which leads to Lewisham, to the Greenwich Railway. This route is now used. The first of the four wires is joined at the

London terminus to one of the Electric Telegraph Company's wires, which leads to Lothbury, whence signals are distributed throughout the kingdom; the second is used for controlling the clock that forms the subject of these remarks; the third is for the hourly time-signal on the South-Eastern district; and the fourth is spare.

"The wires along which the time-signals are distributed to the stations on the South-Eastern district are borrowed automatically by the aid of the clock at London, and for the ball-drop at Deal by the further aid of a clock at Ashford. They must be borrowed at the right time, and only for a short time; they cannot be spared long from their ordinary telegraph duties. And for the Deal drop it is further necessary that the borrowed wire shall for the time being be perfectly safe from the ingress of false signals from any of the telegraph stations, the clerks at which might, but for the precautions that have been taken, unwittingly send a speaking signal, and make a false drop at Deal, misleading the captains of ships then lying in the Downs.

"When the system first commenced, a Shepherd's electric clock was erected at the London terminus; it is without weight or spring, and its motive power was supplied, second by second, by the aid of the pendulum at the Royal Observatory, which in its oscillation made contacts with certain light springs, and so directed electric currents of the required character from batteries placed at Greenwich to electro-magnets placed within the clock at London. While the gutta-percha wire was new and in good condition, which was for a considerable time, the London clock would, for weeks, and often for months together, continue to show the same second as the Greenwich clock. We were able to verify this by the hourly time-signals on the other wire, already referred to, and which could be read off on a galvanometer placed inside the clock-case at London. This is a very remarkable illustration of the immunity from interruption that is enjoyed by ordinary telegraphic circuits. The failure of a single current would create an error of two seconds in our clock, and yet week after week true time was shown; so that $60 \times 60 \times 24 = 86400$ currents of electricity passed daily in safety from Greenwich Park to London Bridge. At last the gutta-percha began to succumb to time and other influences, and electricity was lost on the road. At first a solitary current now and then throughout the day failed; matters grew worse, the non-arrivals were more frequent, and our clock not only failed in its special purposes, but ceased to be an ordinary timekeeper, and we had often to cover the dial.

"I determined, in future arrangements, to abandon this bold experiment; for, all things considered, and notwithstanding its first successes, it was a bold experiment to place a distance of six miles between the motive power and the

machine—in this case not a small one—to be moved; and as we could not well abandon the clock, fitted as it was with all the apparatus for borrowing the telegraph wires at the selected hours for time-signals; and as we had no convenient place for it, if we had supplied it with the ordinary going power—a weight and a pendulum—I arranged that it should continue to be an electric clock, but should receive the necessary electric currents, second by second, by the aid of a pendulum oscillating in London instead of in the Royal Observatory—the clock to which this pendulum appertains being to be put under the control of the Greenwich clock. The clock selected for this work had originally been an electric clock. I furnished it with a wooden pendulum and a weight, and made other necessary alterations, furnishing it with a dead-beat 'scapement. I availed myself of the electric parts of the clock—at least of such portions of them as served my purpose—leaving them in their original places in the body of the clock, where they were so arranged as to act upon the crutch, and by its means on the pendulum. It will be understood from this that I did not select this mode of controlling a clock in any preference to the admirable method practised by Mr. Jones, of Chester (and adopted by Mr. Hartnup at Liverpool and Mr. Airy at Greenwich), who controls by a bar-magnet and a coil of wire near the lower end of the pendulum; but having to deal with a clock already possessed of electric parts, I sought out how I might best turn them to account *in situ*. This clock has acquired the name of the 'Mechanico-Electric Clock,' which serves very well as a distinctive name. It contains a U-shaped bar of iron, with its ends upward, and surrounded by coils of No. 16 copper wire; this wire is $\frac{1}{16}$ in. in diameter. A brass bar is fixed by its centre upon the arbor that carries the crutch; it is at right-angles to the arbor, and in a horizontal position. Any force applied to this bar moves the arbor; any force applied to the arbor moves the bar. At one end of the brass bar is a bar of soft iron, at right-angles to the brass bar, and also in a horizontal position; it in fact forms, with the brass bar, a T-piece. A counterpoise, capable of adjustment, is fitted to the other arm of the brass bar; the iron bar is situated above and facing the poles of the electro-magnet already described, and is attracted downwards whenever a current of electricity is present in the coils of wire, and, of course, reacts on the pendulum itself by means of the crutch, with which it is solidly connected. The pendulum is tolerably good, and measures very fair time for ordinary purposes. When the clock is set going and left to its own resources, it may vary a few seconds more or less either way during the day. All this time the iron bar or armature approaches to or recedes from the electro-magnet at each alternate oscillation of the pendulum, but is uninfluenced. If, now, from some foreign source, a current of electricity is made to circulate through

the coils at each alternate second, the iron bar, and with it the crutch and the pendulum, are perfectly controlled by these synchronous currents, and the 'mechanico-electric clock' is retained in strict companionship with the clock from which the currents are sent. In the preliminary experiments in the shop, a gaining or a losing rate of twenty or more seconds per hour was put upon the clock; but in either case it was perfectly controlled, and constrained to show the same time as that exhibited by the controlling clock.

"The manner in which the currents are put into circulation by the Observatory clock is simple enough. At London, a wire is led from the earth to one end of a zinc-graphite battery of a few cells; from the other side of the battery a wire goes to the commencement of the coil of the electro-magnet in the clock; from the end of the coil, a wire passes to one side of a galvanometer, fixed on the outer side of the clock-case. I may here mention that this galvanometer forms no necessary part of the system; it is placed here so that the motions of its needle at every alternate second may indicate to those in charge, that the circuits are in order and the currents are duly passing. They can detect also at a glance, by the feeble motion of the needle, when the batteries are getting low. From the other side of the galvanometer, the wire proceeds direct to the Royal Observatory, where it terminates in a slight spring, which is touched by the pendulum at every alternate second. The pendulum, by means of the frame of the clock, to which it is suspended, is connected by a wire to the earth. So that each time the pendulum touches the spring, the telegraph circuit is completed, and the battery current flows. This arrangement has been for several months in operation; and accomplishes all that we had proposed. Week after week, our clock has shown the same second as the clock at Greenwich. The control is effected at a very small expenditure of electric force.

"I have had some experience in the relations that have been established between electricity and time. The conclusions to which I have arrived are, that electricity is out of place as a moving power for clocks. It is an unnecessary refinement; and is far more troublesome than a weight or a spring. But electricity is of very great value as a controlling power. It is an unfortunate circumstance that the pendulums of 8-day dials, of which there are thousands in this country, oscillate in no fraction of a second. There is an established train of wheels; and stereotyped numbers for the wheels and pinions, and these are often intermixed. These dials are the staple time-keepers throughout the country, in offices and places of business. Dozens of them are often found under the same roof. With very little addition to the movement every such group could have been kept in perfect control by the one pendulum of a good regulator, if they were other than they are.

"There is one point in the control of clocks that must not

be overlooked. The same currents that will keep a pendulum that is once in beat always in beat, will also stop the same pendulum altogether, if they arrive at the wrong time; that is, if they arrive so as to oppose its movement. It will not do to establish the electric communication hap-hazard, when the pendulum is at any part of its arc; it must be made to commence so that the motion thus applied to the crutch may coincide or conspire with the then motion of the pendulum. Before erecting the clock, and while it was in the shop, I made many experiments on this point, and invariably stopped the clock, when I applied the current at the wrong time. I advised the Astronomer Royal of this peculiarity, and he made some trials on a clock in the Observatory, which was controlled near the bob, on Mr. Jones's plan; and with the same results. This delayed me for some months in putting my clock to the test of real work; because the wires between London and Greenwich were at that time still in a defective state; and I could not depend upon the regular appearance of currents. I made the trial; but when the currents flagged for a time and then recovered their strength, it happened as often as not that they reappeared at the wrong moment, and the clock was repeatedly stopped; so that I was glad to leave the clock to its own resources until the wires were repaired. Since that time, we have had no recurrence of the interruption save in one instance; when from some cause the Observatory clock was at rest for a short time, and of course ceased to give signals; and when again set in motion, the currents caught our pendulum at the wrong time.

"I have since made a provision against these contingencies; but have not had an opportunity to adjust it, nor, indeed, any occasion to bring it into operation. I have divided the Greenwich wire as it enters the clock, and before it arrives at the galvanometer. A pair of light springs are at the division. When the Greenwich pendulum touches the spring there, this pair of springs must also be in contact, or no current can pass. The springs are pressed together by the pendulum as it oscillates against them; and I have so arranged them that they cannot be pressed together by the pendulum unless it is in that particular position in its arc, when the controlling power is valuable. In no other position therefore, in no unfavourable position of the pendulum can the current enter, and the clock will not be stopped. All that happens is that the error, be it a gain or loss, accumulates till it amounts to two seconds; and then the Greenwich and London pendulums are again in beat together, and continue so."

Abstract of his latest Results. By Prof. Wolf.

(*Translation communicated by Mr. Carrington.*)

Some fine series of observations of Flaugergues, Adams, Arago, and others, have enabled me to fill in previous breaks, and to express in the same unit my Relative numbers (for the abundance of Solar Spots in successive years) for the years from 1749 to 1860. They are as follows:—

1749	63·8	1777	63·0	1805	50·0?	1833	7·5 *m*
1750	68·2 M	78	94·8	06	30·0?	34	11·4
51	40·9	1779	99·2 M	07	10·0?	35	45·5
52	33·2	1780	72·6	08	2·2	36	96·7
53	23·1	81	67·7	1809	0·8	37	111·0 M
54	13·8	82	33·2	1810	0·0 *m*	38	82·6
55	6·0 *m*	83	22·5	11	0·9	1839	68·5
56	8·8	84	4·4 *m*	12	5·4	1840	51·8
57	30·4	85	18·3	13	13·7	41	29·7
58	38·3	86	60·8	14	20·0?	42	19·5
1759	48·6	87	92·8 M	15	35·0?	43	8·6 *m*
1760	48·9	88	90·6	16	45·5 M	44	13·0
61	75·0 M	1789	85·4	17	43·5	45	33·0
62	50·6	1790	75·2	18	34·1	46	47·0
63	37·4	91	46·1	1819	22·5	47	79·4
64	34·5	92	52·7?	1820	8·9	48	100·4 M
65	23·0	93	20·7?	21	4·3	1849	95·6
66	17·5 *m*	94	23·9	22	2·9	1850	64·5
67	33·6	95	16·5	23	1·3 *m*	51	61·9
68	52·2	96	9·4	24	6·7	52	52·2
1769	85·7 M	97	5·6	25	17·4	53	37·7
1770	79·4	98	2·8 *m*	26	29·4	54	19·2
71	73·2	1799	5·9	27	39·9	55	6·9
72	49·2	1800	10·1	28	52·5	56	4·2 *m*
73	39·8	01	30·9?	1829	53·5 M	57	21·6
74	47·6?	02	38·3?	1830	59·1	58	50·9
75	27·5 *m*	03	50·0?	31	38·8	59	96·4
1776	35·2	1804	70·0? M	1832	22·5	1860	98·6 M

If these numbers are laid down graphically, there results a curve-line consisting of numerous waves. It is unquestionable that the length of these waves is variable, and all the epochs of minimum since the discovery of solar spots are very nearly given by the formula

$$
\begin{aligned}
t_x = 1732{\cdot}823 &+ 11{\cdot}119 \,.\, x \\
&+ 1{\cdot}621 \,.\, \sin\left(146^\circ + x \,.\, \frac{360^\circ}{15}\right) \\
&+ 1{\cdot}405 \,.\, \sin\left(230^\circ + x \,.\, \frac{360^\circ}{5}\right)
\end{aligned}
$$

If the two last variable terms in this formula are neglected, we have the mean epochs of Minimum; and if we compare these with the epochs given by the observations, and with the height of the Maxima expressed by the Relative numbers, we find there is a very remarkable connexion, which the following table places clearly in evidence: —

True Minimum.	True — Mean Minimum.	Diff.	Rel. No. of Max.	Diff.	True Maximum.
1744·5	+0·588				
		+	68·2		1750·0
1755·7	+0·639			+	
		—	75·0		1761·5
1766·5	+0·320			+	
		—	79·4		1770·0
1775·8	—1·449			+	
		—	99·2		1779·5
1784·8	—3·618			—	
		+	90·6		1788·5
1798·5	—1·037			—	
		+	70·0		1804·0
1810·5	—0·156			—	
		+	45·5		1816·8
1823·2	+1·425			+	
		—	53·5		1829·5
1833·8	+0·906			+	
		—	111·0		1837·2
1844·0	—0·013			—	
		+	110·4		1848·6
1856·2	+1·068			—	
			98·6		1860·5

The constant opposition of signs can hardly be regarded by any one as accidental, and if admitted to be regular, we have manifestly this law,—*greater activity on the Sun goes with shorter periods, and less with longer periods.* I believe this law to be one of the most important relations among the Solar actions yet discovered, and which, taken in connexion with the results for distribution in heliographical latitude, and corresponding apparent periods of rotation, promises to throw much light on this difficult subject, and perhaps even on the phenomena of Variable Stars.

Zurich, 1861, *Jan.* 19.

Mr. Carrington wishes to call attention to the question of the determination of the figure of the Sun, and suggests the measurement for this purpose of photographic pictures of the disk. By aid of a reference given by Mr. Carrington, the Editor has found as follows:—

The question is discussed in a memoir by Mossotti, "Formole per determinaire gli Assi del Sole supposto uno spheroide ellittico, con applicazioni," in the Appendix to the Milan Ephemeris for 1820. The figure is in the first instance assumed to be an ellipsoid with three unequal axes, but supposing it to be a spheroid of revolution the formulæ are as follows: (for greater convenience D_v, D_h, are written in the place of the single quantity D′, which is used in the memoir to denote successively the vertical and horizontal semi-diameters):

D denotes the equatoreal diameter as it would be seen at the mean distance 1; D_v and D_h the vertical and horizontal diameters reduced to the mean distance 1; e the excentricity of the spheroid ($= 1 - \frac{c^2}{a^2}$ if a, c, are the equatoreal and polar semi-diameters). Then

$$D - D_v = \tfrac{1}{2} e^2 D p^2, \quad D - D_h = \tfrac{1}{2} e^2 D p^2_2,$$

and consequently

$$\frac{D_v}{D_h} = \frac{1 - \frac{1}{2} e^2 p^2}{1 - \frac{1}{2} e^2 p_2},$$

or

$$D_h - D_v = \tfrac{1}{2} e^2 (p^2 D_h - p^2_2 D_v),$$

in which last formulæ, it would clearly be unnecessary to reduce the observed diameters to the mean distance 1, since the formulæ contain only the ratio of these diameters. The values of p^2, p^2_2, are calculated by the formulæ in the memoir with the data

Inclination of the solar to the terrestrial equator $= 25^\circ\ 40'$,
Right ascension of ascending node, ditto ditto $= 16\ 50$,

for the middle of each month; viz., the values are

	p^2	p^2_2
January	0·99	0·00
February	0·91	0·07
March	0·82	0·16
April	0·81	0·18
May	0·88	0·12
June	0·97	0·03
July	0·99	0·00
August	0·92	0·06
September	0·83	0·16
October	0·81	0·19
November	0·88	0·12
December	0·97	0·03

The observations of Littrow and Maskelyne referred to in the mèmoir make the figure a prolate spheroid; those of Carlini, an oblate spheroid.

In a paper in the *Ast. Nach.* t. ix. p. 365 (1831), M. Bianchi has applied the above formulæ to observations taken at Modena in the years 1828 and 1829: the figure is found to be an oblate spheroid; but the vertical diameters alone, the horizontal diameters alone, and the two conjointly, give for $\frac{1}{2}e^2$ the very discordant values $\frac{1}{1925}, \frac{1}{110}, \frac{1}{249}$. As to the deduction of the true ellipticity from the observed figure of the disk, see also Mr. Grant's "Note on the correction to be applied to the apparent ellipticity of a Planet, in consequence of the elevation of the Earth above the plane of the Planet's Equator," *Monthly Notices*, vol. xiii. (1853), pp. 192–196.

RECENT PUBLICATIONS.

Théorie du Mouvement de la Lune. Par M. Delaunay (premier volume) being t. xxviii. of the *Mém. de l'Acad. de Paris.*

The following is in substance the account of the work as given by the author in the *Comptes Rendus* (séance du 24 Déc. 1860):—

"I have already had occasion to explain the object of the great work which I undertook fourteen years ago on the theory of the Moon. It is known that my end was to effect a new analytical determination of the lunar inequalities carrying the approximations notably further than had been done before me. Concentrating at first all my efforts on the inequalities due to the disturbing force of the Sun, and admitting in the calculation that the motion of the Sun takes place according to the laws of elliptic motion, I proposed to myself to investigate all the parts of these inequalities which are not of an order superior to the seventh. M. Plana, in his great work on the Lunar Theory, had stopped at the inequalities of the fifth order. The method employed by me consists in a series of operations similar to each other, whereof each has for its object to get rid of one of the periodic terms of the disturbing function by the aid of a simple change of variables. When, by the application of this method, we have removed from the disturbing function the terms of most importance in regard to the magnitude of the inequalities to which they give rise, the question is simplified, and can then be treated as easily as if it related to the inequalities of a Planet or the Sun.

"The volume which is just printed contains a part of the formulæ which I have obtained by operating in conformity with the above method. It is composed of five Chapters. The first is devoted to the establishment of the differential equations, the integration whereof gives the inequalities of the motion of

the Moon; the second, to the development of the disturbing function and of the elliptic values of the Moon's co-ordinates; and the third, to the exposition of the analytical method which I have imagined for integrating the differential equations by dividing the work so as to enable the further development of the approximations in each part. These three Chapters, much less extensive than the others, furnish a kind of introduction to the actual working out of the method, which is developed in the following chapters. The fourth Chapter contains the complete development of the disturbing function, with the different modifications it has successively undergone by means of a succession of 57 operations effected upon it to disembarrass it of the most important terms; this development contains 460 terms. Lastly, the fifth Chapter contains all the details of the establishment of the formulæ relative to the 57 operations in question. The second volume, the printing of which I hope to commence forthwith, will contain, 1°, the different formulæ intended for taking account of the terms which remain in the disturbing function after the foregoing 57 operations have been effected; 2°, the expressions of the three co-ordinates of the Moon with *all* their inequalities to the seventh order inclusive for the longitude and the latitude, and to the fifth order for the reciprocal of the radius vector; 3°, lastly, several chapters intended to complete the expressions for the co-ordinates of the Moon by taking account of all that was provisionally neglected in order to the consideration of only the capital part of the question. Desiring that my work should inspire to astronomers as much confidence as possible, I have neglected none of the means which appeared to me proper for facilitating the verifications which may occur to any of them. In particular I may refer to the indications accompanying the different parts of the disturbing function (Chap. IV.), and which have for their object to show the origin of each part.

"The simplicity and regularity of the method which I have followed, for the inequalities of the Moon's motion, have permitted me to set forth the series of the operations with all desirable clearness, without the necessity of long explanations. Thus, the last two chapters of my first volume, which occupy seven-eighths of the entire volume, consist almost exclusively of formulæ, with very little text. Many of the formulæ are very long; in particular that which forms the whole of Chapter IV., and which covers 138 pages. The printing of the volume presented the greatest difficulties, and it has required all the skill and zeal of M. Bailleul, the Director of the Mathematical Printing Establishment of M. Mallet-Bachelier, to bring the work to a conclusion, and to render all the parts of the volume agreeable to the eye without injury to the perfect clearness of the formulæ."

The Radcliffe Catalogue of 6317 *Stars, chiefly Circumpolar, reduced to the epoch* 1845·0, *formed from the Observations made at the Radcliffe Observatory under the Superintendence of Manuel John Johnson, M.A., late Radcliffe Observer. With Introduction by the Rev. Robert Main, M.A., Radcliffe Observer.* Published by order of the Radcliffe Trustees. 8vo. Oxford, 1860.

The following are extracts from Mr. Main's Introduction:

"The Radcliffe Catalogue of stars contains the result of *all* the Star-observing at the Radcliffe Observatory from 1840 to the end of the year 1853. For the year 1854 only Fundamental Stars are included, and those which were necessary to make more complete the re-observation of Groombridge's Catalogue of Circumpolar Stars; and for the following years as far as 1859, in general such observations only were used as were necessary in order to complete the results of former years for the Stars already included in the Catalogue.

"The compilation of the Catalogue was commenced as early as the year 1850; and at the time of the death of Mr. Johnson the whole of the work was in the hands of the printer, and a few sheets were actually printed off under his superintendence. After his decease the printing of the remainder of the Catalogue went on without serious interruption until its completion, under the superintendence of Mr. Quirling, the First Assistant of the Observatory.

"The chief labour of the comparison of the proofs with the manuscript was performed by Mr. Luff, of whose most valuable and almost gratuitous labours mention is so frequently made by Mr. Johnson in the introductions to separate volumes of the Radcliffe Observations.

"The MSS. used in the compilation of the Catalogue have been with few exceptions bound up and labelled, and they admit of very easy reference.

"On the whole, . . . the equinox employed is that of the *Nautical Almanac* for 1840, without any attempt at independent determination by observations of the Sun.

"The result [of a comparison given in the introduction] is so far satisfactory as showing that the equinox to which the Right Ascensions of the Radcliffe Catalogue have been referred does not differ materially from that of the Greenwich Twelve-year Catalogue; but there is a variation in the differences of Right Ascension for different hours, which is too well marked to be accidental, and of which I am unable to give any account. From x^h to xv^h, namely, the mean of the difference is $0^s{\cdot}09$, while the mean for the remaining hours is only $0^s{\cdot}025$.

"There is no doubt but that this anomaly depends on something which has affected the Radcliffe observations or their process of reduction, because similar differences are found to

exist in the mean Right Ascensions of the Fundamental Stars as deduced by *Wolfers* for the year 1860, as compared with Johnson's results from the observations of 1854 and 1855 reduced to 1860, as given in the sixteenth volume of the Radcliffe Observations. Still the origin of it is very obscure, and after thinking of many possible causes I do not find one which is altogether adequate. It may be, however, remarked that the hours of Right Ascension for which the differences are greatest, are those which correspond to the Spring and early Summer months for evening observations of the stars in those hours.

"As the principal object which Mr. Johnson had in view in star-observing was the complete re-observation of the stars in Groombridge's Catalogue, all in that Catalogue have been looked for with great care, and with very few exceptions all have been re-observed.

"In consequence of the lamented death of Mr. Johnson, the publication of the Radcliffe Catalogue has been delayed considerably beyond the time which would have been necessary if he had been spared to see the printing of the work completed. In fact, the printing was completed about the middle of last year [1859], and has waited only for the introduction and general revision, which could be performed only by a person authorised to assume the direction of the Observatory. On my appointment to the office of Director in June last, the study of the details of the computations was one of my earliest cares; and I did not rest satisfied till I had convinced myself, by a searching scrutiny, of the accuracy of all the elements and of all the processes employed, and had put myself into a position enabling me to hold myself responsible for the general accuracy of the work. I found, however, that it would not be prudent to proceed to the publication of it until I had come into residence; and since that time, or from October 1st [1860], I have been employed upon it as incessantly as my other duties permitted; and I now confidently offer it to the world as a work well sustaining the reputation of the late Director, and as one of the most important and accurate of modern Star Catalogues."

Catalogo di 1321 *Stelle Doppie misurate col grande Equatoriale de Merz, osservate all' Osservatorio del Collegio Romano, e comparate colle Misure anteriori.* Del P. A. Secchi. Roma, 1860.

An account of the work is given by the author in the *Comptes Rendus*, t. li., (17 Dec. 1860). The work is the fruit of the observations of five years. It contains the measures of 1321 Double and Multiple Stars, made with the great equatoreal of Merz, and compared with the anterior measures of

Struve, Mädler, and other astronomers for the determination of the motions.

The following are some of the conclusions from this review of nearly 7600 complete observations of stellar systems:

1°. The number of Stars in the first four orders of Struve, the motion of which is established, is to the total number of Stars observed in the following proportion:

Order 1,	stars in motion,	to all the observed stars,	as	1 : 2
,, 2	,,	,,		1 : 3
,, 3	,,	,,		1 : 6
,, 4	,,	,,		1 : 12

The review of these four orders comprises all the *Lucidæ* and a great part of the *Reliquæ* of the *Mensuræ* of Struve; it embraces also a large number of the stars of the catalogues of Pulkova, of Herschel at the Cape of Good Hope, of Smyth, &c.

2°. As it is important to fix the attention of astronomers on the stars the motion of which is ascertained, in order to the perfecting of the observations, and the avoidance of a loss of time in the measurements of fixed objects, there is given at the end of the Catalogue a recapitulation of the Stars measured, distinguishing them into the classes of certain motion, of doubtful motion, or of no motion. Denoting them by Struve's numbers, the Stars of certain motion are,

First order.

L. Nos. 2 13 73 205 216 257 333 412 460 511 1356 1457 1670 1728 1819 1937 1938 1967 2055 2084 2215 1315 2438 2509 2574 2729 3062.

R. 234 236 278 840 1426 1457 1663 2402.

Second order.

L. Nos. 113 138 186 228 262 305 314 400 408 535 566 577 945 948 1037 1126 1157 1187 1196 1338 1348 1476 1517 1523 1555 1647 1687 1768 1781 1865 1883 1932 1944 1998 2032 2107 2114 2171 2281 2289 2369 2437 2525 2579 2744 2799 2881.

R. 183 208 498 1081 1757 1837 1876 2106 2356 2434 2491 2544 2662 2856 2934 3047.

Third order.

R. Nos. 91 202 389 572 742 997 1273 1424 1536 1777 1785 1788
1909 1954 1988 2021 2052 2130 2382 2383 2576 2603 2624 2644
2804 2909 3001 3050.
158 195 249 355 403 932 1439 1450 1658 1722 1842 2026
2097 2120 2205 2303 2309 2484 2541 2828 2900 2942 3046.

Fourth order.

L. Nos. 422 589 982 1066 1110 1263 1306 1543 1888 2272 2725 2822
2928 2944 3008.
R. 44 122 295 1300 1830 1925 2165 2455 2538 2877 2976.

Fifth order.

60 550 668 1516 2732 2708. —— 2220 2262 142.

These numbers include all the Stars the orbital motion whereof is known. But in order to decide as to many others, in particular of the *doubtful* ones, it will be necessary to wait another quarter of a century, the interval which separates these from the observations of M. Struve. The author proposes to continue his observations on the doubtful class, and for the more distant orders, the review whereof is still imperfect.

Mémoire sur la Détermination des Distances polaires des Etoiles Fondamentales. Par E. Laugier, Membre de l'Institut, Astronome adjoint du Bureau des Longitudes, &c. (forms part of t. xxvii. of the *Mémoires de l'Acad. des Sciences*), Paris, 1859.

The observations were made at the Paris Observatory in the years 1851–1853, with the Mural Circle of Gambey. The memoir is divided into two parts; the first contains, 1°, the description of the Mural Circle; 2°, the series of rough observations made by the author with the instrument; they are collected in tables placed at the end of the text; 3°, all the necessary details in regard to the instrumental corrections to be applied to the observations and in regard to the elements of reduction; 4°, the determination of the colatitude of the Mural Circle and of the polar distances of the observed Stars.

In the second part the author discusses the declinations of 140 stars, published in the different Catalogues, and he deduces a normal Catalogue with which he compares the others. Lastly, starting from the normal declinations he determines anew the colatitude of the Mural Circle by means of the zenith distances given in the first section.

The epoch of the normal polar distances is January 1, 1852. The colatitude, as deduced from the Circumpolar Stars, is $41^\circ\ 9'\ 48''\cdot66 \pm 0''\cdot05$, and as deduced from the normal positions and zenith distances of the Fundamental Stars is $41^\circ\ 9'\ 48''\cdot72 \pm 0''\cdot04$.

Posizioni Medie de 2706 Stelle pel 1° Gennajo 1860 distribuite nella Zona Compresa fra 10° et 12° 20′ de Declinazione Australe dedotte delle Osservazione fatte negli Anni 1856–57–58, nell' I. R. Osservatorio di Padova. Memoria di Giovanni Santini. 4°, Venezia, 1858. (Estr. dal volume vii. delle Memorie dell' I. R. Istituto Veneto.)

The memoir is a sequel to two others published in vols. v. and vi. of the *Nuovi Saggi dell' Accademia di Padova*, containing a catalogue of stars between the parallels of 10° north declination and 10° south declination. The epoch of the catalogue is, as stated, in the title, Jan. 1, 1860. The right ascensions and declinations of the observed stars are compared with those in the catalogue of Weiss.

Sur les Lois du Mouvement propre des Etoiles du Catalogue de Bradley. Par M. Kowalski. 8vo. pp. 1–90, 1859.

The object of the memoir is to investigate whether the proper motions, and consequently the true motions in space, of the Stars of Bradley's Catalogue, are subjected to any other laws than those which follow from the motion of the planetary system, and what consequences can be deduced from them with reference to the structure of the Stellar Universe and the forces which govern it. The results deduced by M. Mädler from the proper motions of the stars in the Catalogue in question serve as the basis of the investigations of the memoir. The Catalogue of Bradley contains 3222 stars; of these there are only 86 the proper motions of which are not known, and the materials are thus furnished by 3136 stars. The conclusions arrived at are not stated so explicitly, as that, without risk of misrepresentation, a *résumé* of them can be given, but the memoir will probably be read with interest by those who have occupied themselves with the speculations of Stellar Astronomy.

Note relative à une Courbe du Sixième Degré qui se présente en Astronomie. Par E. de Jonquières. Tortolini, t. i. pp. 112–116. (1858.)

The formula for the Equation of Time, as a function of the true longitude of the Sun, was put by Lagrange in the form—

$$E = -462 \sin(\phi - \alpha) - 593 \sin 2\phi - 3 \sin 2(\phi - \alpha) + 13 \sin 4\phi,$$

where ϕ is the longitude of the sun, α that of the aphelion [? apogee], and E is given in seconds of time.

Neglecting the last two terms, which are of comparatively small magnitude, and putting $\frac{1}{2}\frac{E}{593} = \varrho$, $\frac{231}{593} \sin \alpha = a$, $\frac{231}{593} \cos \alpha = b$, this gives the equation

$$\varrho = a \cos \phi - b \sin \phi - \sin \phi \cos \phi,$$

which may be considered as the polar equation of a curve, the radius vector whereof is proportional to the equation of time.

The note belongs, not to Astronomy, but to Modern Geometry, and contains a very interesting discussion, from that point of view, of the properties of the above-mentioned curve; but the figure of the curve, in which the radius vector gives the value of the equation of time on the scale of one minute of time to a centimetre of length, shows very distinctly the march of the equation of time throughout the year. The curve consists of four loops of unequal magnitudes, giving, therefore, a quadruple point at the origin; but, besides this, the largest loop (which corresponds to the months September to December) overlaps the two adjacent loops, so that there are two double points, one on each axis. The figure might with great propriety be introduced into elementary treatises of Astronomy.

Among the presents to the Society were two handsomely bound manuscript volumes, in folio, containing Logarithms and other Mathematical Tables by the late Thomas Wright Hill, F.R.A.S.; and, in particular, Computations for a Table of Logarithms to 23 places, whereof 21 or 22 will be accurate for all composite numbers from 1 to 220000, originally commenced to 17 places for 15 true places, and now afterwards extended to the 23 places.

The volumes were presented by the author's son, Matthew Davenport Hill, Q.C.

ERRATA.

P. 52, lines 3, 4, 6. The power *should be* 474 *instead of* 174, the diameter of the field of view 5′·68 *instead of* 5″·68, and the major axis of the nebula 89″ *instead of* 89′.

CONTENTS.

Printed by STRANGEWAYS and WALDEN (late G. Barclay), Castle St. Leicester Sq.
and Published at the Apartments of the Society, February 7. 1861.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI. *Feb.* 8, 1861. No. 4.

THE Annual General Meeting of the Society, Rev. R. MAIN, President, in the Chair.

Edward Brailsford Bright, Esq., 2 Exchange Buildings, Liverpool;
Joseph Beck, Esq., C[illegible]n Street;
Richard Inwards, Esq., 18 Albert Street, Camden Road;
James Symmers, Esq., Dollar;
Rev. Edward Frimstone, Winchester;
Samuel Mason, Esq., Redhill, Reigate; and
Joseph Bonomi, Esq., 5 A Portsdown Road, Maida Hill,

were balloted for and duly elected Fellows of the Society.

At the Meeting in January, James Lees Kenworthy, Esq., The Park, Ealing, was balloted for and duly elected a Fellow of the Society.

Report of the Council to the Forty-first Annual General Meeting of the Society.

The year on which the Council now report has not, perhaps, been marked by any occurrence of the first order of importance.

Nevertheless, it will be found to have done its part towards the progress of the science; those useful labours which are always preparing great results have been sedulously pursued.

The Report of the Auditors, subjoined, will show the state of the finances:—

RECEIPTS.

	£	s.	d.
Balance of last year's account	264	15	7
By dividend on £1900 Consols	26	19	2
By ditto on £3500 new 3 per Cents	101	14	5
By ditto on £2000 Consols	28	15	0
By cash of East India Government	75	0	0
On account of arrears of contributions	111	6	0
128 contributions (1860–61)	268	16	0
7 compositions	147	0	0
21 admission-fees	44	2	0
14 first year's contributions	26	5	0
2 contributions for 1862	4	4	0
1 contribution overpaid (to 1862)	1	1	0
Sale of Publications	67	5	0
	£1167	3	2

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:—						
Mr. Cayley, 1 year as Editor of the Society's Publications	60	0	0			
Mr. Williams, 1 year as Assistant-Secretary	100	0	0			
Ditto commission on collecting £522 19s.	26	3	0			
				186	3	0
Investments:—						
Investing £100 3 per Cent Consols				94	7	6
Taxes:—						
Property Tax, 1 year	1	17	6			
Assessed and Land, ditto	3	2	6			
				5	0	0
Bills:—						
J. Basire, engraver	3	1	3			
Troughton and Simms	5	17	0			
Geo. Barclay, printer	355	6	0			
Strangeways and Co., printers	75	6	6			
Smith and Co., engravers	4	2	6			
Malby and Son, lithographers	14	15	0			
J. Rumfit, bookbinder	7	11	0			
J. Taylor, matting	3	15	9			
Willis, dinner	3	10	0			
Mrs. Jones (Lee Fund)	3	5	6			
				476	10	6
Carried forward				£762	1	0

				£	s.	d.
Brought forward				762	1	0
Miscellaneous items:—						
Charges on books, and carriage of parcels ...	4	13	9			
Postage of *Monthly Notices*, letters, &c.	42	8	0			
Porter's and charwoman's work	23	18	9			
Tea, sugar, biscuits, &c. for evening meetings	13	13	0			
Waiters attending meetings	3	17	0			
Coals, &c.	12	0	0			
Sundry disbursements by the Treasurer	26	1	8			
Sundry payments out of Turnor Fund	1	9	6			
Deduction on country cheque	0	1	3			
				128	2	11
Balance at Banker's				276	19	3
				£1167	3	2

Assets and present property of the Society, Feb. 8, 1861:—

				£	s.	d.
Balance at Banker's				276	19	3
4 contributions of 3 years' standing	25	4	0			
21 ——— of 2 ditto	88	4	0			
17 ——— of 1 ditto	35	14	0			
On account of arrears	6	0	0			
				152	2	0
Due for publications of the Society				1	9	0
£3500 new 3 per Cents.						
£2000 Consols (including the Lee Fund).						
Unsold publications of the Society.						
Various astronomical instruments, books, prints, &c.						
Balance of Turnor Fund (included in Treasurer's account) ...				45	3	4

The Fellows will doubtless remark that the expenses of printing have increased to an extent which, unless some measures of retrenchment be adopted, may soon lead to a diminution of the capital of the Society. The new Council will, beyond a doubt, give this matter the most serious consideration. Since there can be no doubt that the quantity which may be printed with advantage to the cause will increase, and not diminish, it is clear that the savings of the Society must not be permanently relied on, beyond the income they produce. Hitherto, there has been found no necessity to refuse printed circulation to any matter of even moderate importance, but it is to be feared that the time is near at hand when, unless the Society should continue rapidly to increase in numbers, communications of real value must be either rejected or prejudicially abridged. The Council think it right to make this communication at the earliest moment, and while it is a matter of prediction, not of experience.

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	27	IX.	193	XXI. Part 1 (separate).	204
I. Part 2	69	X.	205	XXI. Part 2 (separate).	100
II. Part 1	86	XI.	216	XXI. (together).	122
II. Part 2	51	XII.	222	XXII.	217
III. Part 1	111	XIII.	240	XXIII.	217
III. Part 2	130	XIV.	223	XXIV.	229
IV. Part 1	126	XV.	207	XXV.	235
IV. Part 2	139	XVI.	228	XXVI.	251
V.	159	XVII.	207	XXVII.	510
VI.	179	XVIII.	207	XXVIII.	478
VII.	202	XIX.	220		
VIII.	188	XX.	216		

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patronesses, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1860 ...	155	193	32	4	384	51	435
Since elected	8	21	...	...	...	...	...
Deceased	−3	−3	−1	...	...	...	...
Resigned	...	−1	...	...	...	...	...
Removal	1	−2	...	...	...	...	...
Name removed for non-payment of admission fee, &c.	...	−1	...	...	...	...	...
February 1861 ...	161	207	31	4	403	51	454

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,

The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock,
The *Wollaston* telescope,
The *Lee* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{1}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.
18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.
19. 5-inch reflecting circle, by Lenoir.
20. Reflecting circle, by Jecker, of Paris.
21. Box sextant and 3-inch plane artificial horizon.
22. Prismatic compass.
23. Mountain barometer.
24. Prismatic compass.
25. 5-inch compass.
26. Dipping needle.
27. Intensity needle.
28. Ditto ditto.
29. Box of magnetic apparatus.
30. Hassler's reflecting circle, with artificial horizon roof.
31. Box sextant and 2¼-inch glass plane artificial horizon.
32. Plane speculum artificial horizon and stand.
33. 2½-inch circular level horizon, by Dollond.
34. Artificial horizon roof and trough.
35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.
36. A pentagraph.
37. A noddy.
38. A small Galilean telescope, with the object lens of rock-crystal.
39. Six levels, various.
40. 18-inch celestial globe.
41. Varley stand for telescope.
42. Thermometer.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Wollaston* telescope, to Mr. Rees.
The *Lee* circle, to Mr. Burr.
The *Beaufoy* clock, to Dr. Booth.

The *Sheepshanks* instrument,		No. 1, to Mr. Lassell.
Ditto	ditto	No. 2, to Mr. De La Rue.
Ditto	ditto	No. 3, to Rev. C. Pritchard.
Ditto	ditto	No. 4, to Mr. Carrington.
Ditto	ditto	No. 5, to Mr. Birt.
Ditto	ditto	No. 6, to Rev. J. Cape.
Ditto	ditto	No. 8, to Prof. Wheatstone.
Ditto	ditto	No. 19, to Mr. Dayman.
Ditto	ditto	No. 25, to ditto.

The *Sheepshanks* instrument, No. 41, to Rev. C. Pritchard.
Ditto ditto No. 10, to Rev. C. Pritchard.
The double-image micrometer, to Mr. Hodgson.
The *Sheepshanks* instrument, No. 23, to Mr. Spottiswoode.
The 6-inch circular protractor, to Mr. Birt.

Nothing definite has yet been ascertained respecting the other *Beaufoy* clock, the two invariable pendulums, and the quadrant (said to have been *Lacaille's*), reported for many years past as being in the possession of the Royal Society.

A telescope belonging to the late Rev. R. Sheepshanks, found in the stock of Mr. Simms, has been added to the collection by Miss Sheepshanks.

The Council have awarded the Gold Medal to M. Goldschmidt of Paris, for his astronomical labours, especially for those which have resulted in the discovery of 13 of the Minor Planets. The President will explain the grounds of this award before the Meeting closes.

The twenty-ninth volume of the *Memoirs* of the Society has almost the whole of it passed through the press, and will shortly be ready for publication. It contains more than the usual number of papers, some of them of great importance. The first is a paper by the Astronomer Royal, giving the corrections of the elements of the Moon's orbit, deduced from the lunar observations made at the Royal Observatory at Greenwich from 1750 to 1851; being the extension of a preceding memoir based upon the observations from 1750 to 1830. The year 1851 was fixed on as the definitive limit of the reductions, partly by reason that the date of publication of Mr. Adams's researches on the lunar parallax enabled the use of a corrected parallax in the daily reductions from the beginning of 1852, partly because it was known that Prof. Hansen's tables were advancing, and would probably be ready for adoption in the *Nautical Almanac* at no distant time. The Council cannot but congratulate the Fellows of the Society on the publication in their *Memoirs* of a paper containing the completion of the results deduced from such a series of observations.

Captain Clark has contributed a memoir on the Figure of the Earth, undertaken in reference to the investigations in General T. F. de Schubert's "Essai d'une Détermination de la véritable Figure de la Terre." Whatever the real figure of the Earth may be, if in the investigation it is taken to be an ellipsoid, it is clear that the arithmetical process must bring out an ellipsoid of some kind or other, agreeing better with all the observed latitudes, as a whole, than any spheroid of revolution will do. And although it cannot be said that the Earth is thereby *proved* not to be a spheroid of revolution—

the data being in fact insufficient for this purpose—it is in the meantime interesting to ascertain what ellipsoid does actually best represent the existing measurements. This investigation is accordingly undertaken in the memoir, and the dimensions of the axes, and position in longitude of the equatoreal major axis, together with the probable errors of these quantities, are obtained; it appears, however, from the magnitude of the probable errors that the data are not sufficient to bring out the excentricity of the equator with anything like certainty.

Mr. William Ellis has contributed a paper on the Periodical Variations of Level and Azimuth of the Transit Circle at the Royal Observatory, Greenwich. The tables and diagrams bring out very clearly the character of the periodical variations, depending chiefly on the temperature, to which the instrument is subject.

Sir Thomas Maclear has communicated the Observations of Donati's Comet, made at the Royal Observatory, Cape of Good Hope, between October 11th, 1858, and March 14th, 1859. Observations for orbit were the primary consideration, and two series were made, one by Mr. Mann, with the $8\frac{1}{2}$-feet equatoreal, comprising the whole interval of visibility, the other with the 46-inch telescope by the Director himself and G. W. H. Maclear conjointly, in October and November as long as the observations with that instrument were practicable.

Lord Wrottesley has communicated a Catalogue of the Positions and Distances of 398 Double Stars; the result of observations made at the Observatory at Wrottesley by his assistants, Messrs. Simms, Philpot, and Frederick Morton, but the far greater part of them since the beginning of the year 1854 by Mr. Frederick Morton. The working catalogue of stars for observation was selected from Struve's great catalogue of 1837; and contained, 1°, stars confessedly binary; 2°, others of which there was strong presumptive evidence of their being so; 3°, stars of which the observations by different observers gave anomalous or discordant results. As these objects were worked out, more were added from time to time from among the finer and closer of the double stars, and from those which had only been observed at one epoch; some of these latter exhibit orbital motion.

The President has contributed a paper on the Value of the Constant of Aberration, as deduced from Eight Years' Observations of γ *Draconis*, made with the Reflex Zenith Tube, at the Royal Observatory, Greenwich, which may be considered as a supplement to his paper in the twenty-fourth volume of the *Memoirs*, on the Values of the Constants of Aberration and Nutation, as deduced from the observations of the same star with the 25-foot zenith-tube, dismounted in the year 1842. The resulting value of the constant of aberration is very nearly $20''\cdot34$, and the author considers that considerable credit is due to this determination. There is, however, as in the former series

of observations, a negative value of the parallax; being in the present series $-0''{\cdot}24$, which is ten times as great as the probable error, and is therefore an indication of something having affected the observations injuriously, although not to so large an amount as in the case of the 25-foot zenith-tube.

Mr. Cayley has contributed two papers. The first of them, Tables of Developments of Functions in the Theory of Elliptic Motion, contains the developments in multiple cosines and sines of the mean anomaly as far as e^7, of certain powers of the elliptic quotient radius $\frac{r}{a}$, or of its variable part $\left(\frac{r}{a}-1\right)$, multiplied in either case by a cosine or sine of a multiple of the true anomaly. The tables are based upon a formula given by M. Le Verrier, and were calculated under Mr. Cayley's superintendence, by Messrs. Creedy and Davis, by aid of a grant from the Donation Fund at the disposal of the Council of the Royal Society.

The second of the two papers is on the Rotation of a Solid Body, and contains an investigation of the formulæ for the variation of the elements in the disturbed motion, by a method similar to that employed in the author's memoir on the Theory of Disturbed Elliptic Motion, published in the twenty-seventh volume of the *Memoirs*. The author calls attention in the paper to the employment of the quantity g varying uniformly with the time but used as an element, and which corresponds to the mean anomaly in the theory of elliptic motion.

The volume contains also a paper by Mr. Spottiswoode, on a Method of Determining Longitude by means of Observations of the Moon's greatest Altitude; intended to suggest a method whereby at certain parts of the Moon's orbit and under favourable circumstances, the longitude may be obtained by means of a simple sextant observation. Although not so accurate as some others already in use, and restricted as to the times at which it is applicable, it was thought that a method in which both observation and calculation are simple, might not be without use either as supplementary to more elaborate processes, or as a substitute for them when they are not practicable, and the method in the memoir is suggested in that view.

The concluding paper in the volume is one by Mr. Carrington, on the Distribution of the Perihelia of the Parabolic and Hyperbolic Comets in relation to the Motion of the Solar System in Space. If the Solar System be moving in the direction from α *Columbæ* to π and μ *Herculis*, there ought then, if such Comets are chance visitors, to be an excess of perihelia in the hemisphere of which α *Columbæ* is the pole, or computing for each orbit the angle between α *Columbæ* and the perihelion, the mean of these angles should be less than 90°. It appears, however, by the tables which are given, that the mean of the angles for the 133 orbits considered is in fact 95° 36′; the author remarks that this is a result which superior evidence compels us to regard as

nugatory and vitiated by uncontrolled conditions, among which the principal is probably the unequal distribution of observers in the northern and southern hemispheres.

An elaborate paper by Sir J. W. Lubbock, on the Lunar Theory, will probably be printed in the thirtieth volume of the *Memoirs*. The paper relates chiefly to the correction of the numerical values of the coefficients of the different lunar inequalities; but it contains also an investigation sustaining Prof. Adams' value of the controverted term $\left(\frac{3771}{64} m^4 e'^2\right)$ in the expression for the acceleration, and some other theoretical investigations.

The Council regret the loss by death of the following members:—Sir W. Dennison; John Hamilton, Esq.; J. W. Long, Esq.; Charles May, Esq.; Rev. Baden Powell; William Simms, Esq.; and of a late member, Professor Narrien.

The following account of Sir Thomas Brisbane could not be prepared in time for the last Annual Report, the news of the death of its lamented subject being then quite recent.

General Sir THOMAS MAKDOUGALL BRISBANE, Baronet, &c., was of an ancient family, and was born in August 1773; he died January 28th, 1860, in his eighty-seventh year. It is totally impossible to enter upon his career and services. The following abstract is substantially extracted from a publication made by his family:—

Sir Thomas entered the army in 1790, and fought in the first battle of the war, in May 1793, and in the subsequent actions. He went to the West Indies in 1796, and was present at the taking of all the islands under General Sir Ralph Abercromby. He went to the Peninsula in 1812, and commanded a brigade in six general actions, under the Duke of Wellington. He fought in fourteen general actions and twenty-three great affairs, and assisted at eight sieges. He crossed the tropics twelve times, the equinoctial twice, circumnavigated the globe, was in North America, South America, the North of Europe, the Mediterranean, and Australia. In the winter of 1794 he slept for six nights in the snow, with nothing but his cloak and the canopy of heaven over him: he was frozen to the ground in the morning, and during one of these nights 900 soldiers were frozen to death. He was the oldest officer in the army, as he had sixty-nine years of military service.

Sir Thomas Brisbane's devotion to Astronomy began, according to his own account, during his voyage to the West Indies, when the incidents of a gale of wind made him alive to the great use of which navigation and nautical astronomy might be, even to a military man. When in the Peninsula, he regularly found the time by a pocket-sextant, chronometer, and artificial horizon.

During the time he spent in Paris, from 1815 to 1818, with the army of occupation, Sir Thomas Brisbane was instrumental in preventing a rabble of German soldiers from pulling down the buildings of the Academy of Sciences, and in grateful testimony of his services he was thereupon elected a corresponding Member of the Institute.

Sir Thomas Brisbane married in the year 1819 the eldest daughter of Sir Henry Hay Macdougall, Bart., of Makerstoun; through whom he became entitled to the estate of Makerstoun, near Kelso, in addition to his own paternal property of Brisbane.

When the question of sending Sir Thomas to the Government of New South Wales was before the Ministry, Lord Bathurst informed the Duke of Wellington that he wanted a man to govern, not the heavens, but the earth. Sir Thomas appealed to the Duke to say whether science had ever stood in the way of duty. "Certainly not," said the Duke; "I shall say that you were never in one instance absent or late, morning, noon, or night; and that, in addition, you kept the time of the army." Walter Scott wrote of him, that though full of science, he bored no one with it, and was full of general information.

Sir Thomas Brisbane founded three Observatories: one in his public capacity, at Paramatta; two on his own property, at Brisbane and at Makerstoun: at which last place he also founded a magnetic Observatory. In 1828 he received our Gold Medal for his series of observations at Paramatta. The address delivered by Sir John Herschel on its presentation renders it unnecessary to say more at this time.

Brisbane passed his long life without the smallest stain—without even an official mishap. Sound judgment and high principle carried him triumphantly through all the difficulties which lie in the way of the soldier and the administrator: his manners must have not a little contributed to his success. It has been absurdly said that a gentleman, to be the perfection of the character, must not bear the stamp either of his country or of his profession: General Makdougall Brisbane was a refutation of both the points of the assertion; for though in the first five minutes he would have been detected as a Scotchman and a soldier, even though his name and title were unknown, he would in as short a time have been known for a gentleman of the highest breeding; and further acquaintance would have proved that the first appearances were not deceitful.

In estimating the scientific character of Sir Thomas Brisbane, we must distinguish between his claims as an able observer and astronomer in his own person, and as a munificent patron and promoter of science. In the former capacity he takes a high rank, and his acquirements were remarkable. He was a good observer with the sextant, and well versed in every part of nautical astronomy generally, so as to be able to fix

the position of every station at which he might happen to be during his military campaigns. He was also well acquainted with the instruments used in fixed observatories, and was himself a good transit-observer. But it is as a patron of science, by the institution of Observatories, and the encouragement and promotion of Astronomy at a time when its needs were greater and the interest taken in it less than they are at present, that his claims on posterity must be based. The institution of the Brisbane Observatory at Paramatta was a noble work, notwithstanding that, from a variety of causes over which he had no control, the results have been in a great measure nugatory. The chief fault seems to have been in the unsteadiness of the transit-instrument, which has made the results of this Catalogue of Stars in a great degree useless; and it is unnecessary, at this interval of time, to try to determine the degree of blame attributable to individuals. It is, however, greatly to be regretted that the operations of an Observatory so important should not have produced results better calculated to repay its founder.

A similar disappointment did not, however, occur in the magnetical and meteorological Observatory which he established at Makerstoun, in addition to the astronomical Observatory already existing. Sir Thomas was fortunate in his choice of observers, and the results have been of considerable importance. For several years the magnetical observations were most ably conducted by Mr. J. A. Broun, who has since become the Astronomer of the Rajah of Travancore; and several papers on magnetism, in addition to the daily work of the observatory, are evidences of the talents and industry of that gentleman.

We may say, indeed, in summing up the claims of this accomplished gentleman and munificent patron of science to the gratitude and admiration of posterity, that they do not depend in any great degree on the absolute success which has attended his efforts. He saw much more clearly than his contemporaries the need of a well-equipped Observatory in the Southern Hemisphere, and he not only built one at his own expense and provided observers, but he used the influence which his position in the colony of New South Wales gave him to diffuse a taste for astronomical science. In a similar way, when co-operation was needed for the determination of magnetical and meteorological elements, he as freely gave his time and his money for the establishment of an Observatory at Makerstoun, and with the best possible results in the latter case. A rigorous sense of duty seems to have been the guiding principle of his long life of activity and usefulness—the duty of using all his advantages for the good of society and for the extension of science; and he has left behind him a name second to few even in this age so prolific in great and noble characters.

Mr. Isaac Long was born in May 1810, and died at Alderly Lodge, Cheshire, May 29, 1860. His father's misfortunes obliged him to maintain himself before his education was completed. While acquiring a handsome independence by long attention to business, he obtained good knowledge of several sciences. He was an industrious observer of the heavens with a 5-inch achromatic telescope equatoreally mounted, and was the first to call attention to some remarkable changes in *Jupiter's* belts. He was an expert photographer, and made a fine collection of geological specimens. He was an active member of local societies, and aided with zeal in the dissemination of scientific knowledge. One of the best features of progress in our time is the number of these men who, while succeeding in mercantile life, are actual labourers in literature and science.

Charles May, F.R.S., was born at Alton in Hampshire, in the year 1800, and at an early age, along with the rest of his father's family, he removed to Ampthill in Bedfordshire. His father belonged to the Society of Friends; his education was of a very limited character, scarcely superior to that of the children of ordinary mechanics of the present day, but the mechanical genius for which he afterwards became so distinguished, began to develope itself at a very early period.

At the usual age he was apprenticed to Mr. Sims, a chemist and druggist at Stockport, whose daughter he afterwards married. At the expiration of his apprenticeship Mr. May returned to Ampthill, where he commenced business on his own account, adding to the ordinary retail business that of a manufacturing chemist on a small scale. He afterwards added a new branch to his business, that of a millwright, the special object being to furnish the requisite machinery for the drug-mills, which, in conjunction with Mr. Stafford Allen, he established in Cowper Street, City Road.

At this period Astronomy became one of his favourite pursuits, and he constructed with his own hands several reflecting telescopes of excellent performance; and although the engrossing nature of his other duties never allowed him to devote much time to practical astronomy, he retained through life a warm attachment to the science.

In the year 1836, Messrs. Ransome of Ipswich, who had for many years carried on the business of agricultural implement-makers, offered him a partnership in their concern, which he accepted, giving up at the same time his other business engagements. Mr. May's department in these works was the *engineering*, and under his vigorous management the concern rapidly grew from a small implement-factory employing about 100 hands to a large engineering establishment known all over the world, and employing 12 or 1300 persons. He remained at Ipswich until the year 1851, when he and Messrs. Ransome

dissolved partnership. He then removed to London and practised as a consulting engineer until his death. Whilst at Ipswich he constructed for the Astronomer Royal the great Transit-Circle and the Altazimuth. These magnificent instruments are justly regarded by all competent judges as models of engineering perfection, and they have inaugurated a new phase in astronomical-instrument-making. Mr. Airy, in one of his Annual Reports to the Board of Visitors, bears willing and grateful testimony to the zeal and ability with which Mr. May carried out his own splendid conceptions.

During his residence at Ipswich Mr. May erected a very elegant and spacious private Observatory, furnished with a transit instrument, clock, and a Merz achromatic telescope of exquisite quality, with an object-glass of 6¾ inches aperture. He also constructed the dome at Hartwell House, which covers the telescope formerly belonging to Admiral Smyth, another large dome for Mr. Barclay of Bury Hill, and the equatoreal mounting for the great object-glass of Ross, which graced the memorable Exhibition of 1851, and formed so conspicuous an object in the nave of the palace of glass.

He also distinguished himself by his improvements in the "permanent way" of railways, and was the first to suggest the application of the process termed "chilling" to the pivots of large instruments. He was the inventor of "compressed treenails" for fastening railway-chairs to the sleepers.

Such was Mr. May in his professional capacity. In private life his amiable disposition and the combination of kindness and humour which he brought to social intercourse, and his readiness to assist others, made him generally beloved. He became a member of this Society in 1835, and served several times on the Council. He was elected a Fellow of the Royal Society in June 1855, and was also a member of the Institute of Civil Engineers. He died suddenly in August last, and few men have gone to the grave more deeply regretted than Charles May.

The late Professor Narrien, of Sandhurst, had retired from the Society, in consequence of ill health, in the year 1858. The Council have not been able to procure any account of his life. He was for many years attached to the Royal Military College, where he was greatly respected and very useful. His name will be preserved by his *Historical Account of the Origin and Progress of Astronomy*, published in 1833. This work, founded on the study of original sources, is an attempt to connect the history of the science with its first elements. It is chiefly devoted to the ancient and middle periods, not extending in detail beyond the time of Newton. There is not, we believe, another work, so nearly popular in its character and appearance, which gives so exact an account of ancient Astronomy. It is a valuable predecessor, both in time and contents, to

the work of Mr. Grant. Mr. Narrien also published some elementary works on mathematics, as part of a course intended for the use of the College in which he taught.

The Rev. BADEN POWELL, F.R.S., was the eldest son of the late Rev. Baden Powell, of Langton in Kent, and was born at Stamford Hill, near London, in 1796. He graduated at Oxford, where he took a first-class degree in mathematics in 1817. In 1820 he entered into holy orders, and in the following year obtained the vicarage of Plumstead in Kent. He was appointed Savilian Professor of Geometry in 1827, and Public Examiner soon afterwards; a post with which he was again honoured in 1831. He thus stood, as it were, the acknowledged representative of mathematical and physical science in the elder English University. We may almost say the only representative; for when he first obtained the professorship, science was at the lowest ebb in Oxford. Mr. Powell exerted himself to bring this state of things before the educated world, by which he incurred some obloquy. But he persevered, and succeeded; the honourable position which Oxford now holds, and the bright prospects of the future, are due in good part to the exposure and remonstrance of the Savilian Professor.

He performed the duties of his chair with urbanity, seeking to encourage his students by explaining and familiarising each point that would allow of it; towards which he had a happy talent of constructing his own models, of the simplest materials, for his practical illustrations. Thus, whenever requested to deliver lectures at public institutions, he came armed with appropriate diagrams and forms that essentially aided the comprehension of those who crowded to hear him. We have thus seen the Undulatory theory of Light treated, and Diffraction made—we may say—palpable. The Precession of the Equinoxes, and the phenomena of Aberration and Nutation, were rendered equally visible; and the hurried progress of Comets when approaching the perihelion, was so attractively shown, that the audience flocked down, after the lecture, to watch the comet vary its speed through its long ellipse towards the sun. His style of delivery was peculiarly quiet, showing his own clear conviction and comprehension of his subject; and his calmness was caused by depth of thought. This sedateness of manner pervaded all his writings and discourses, enabling him even to preach extempore on the most intricate doctrinal points without wandering from his subject.

Meanwhile he had produced various works, as well scientific as theological. Among the first class may be cited his *Treatise on the Differential and Integral Calculus;* and another on the *Geometry of Curves.* In 1834 he published his *History of Natural Philosophy*, and in 1841 the *Undulatory Theory of Light;* besides which he was the author of several papers in the *Philosophical Transactions* on Light, Heat, and

Irradiation. Moreover, his tracts appear in the records of this Society, the Ashmolean collections, and the volumes of the British Association. In the other order of his writings we have to enumerate—besides those for the elucidation of pure religion—the *Connection of Natural and Divine Truth*, 1838; the *Unity of Worlds*, 1855; *Christianity without Judaism*, 1857; on the *Study of the Evidences of Christianity*, 1860, &c.

During the last years of his life Mr. Powell was a controversial theologian. His writings were of a cast which is called liberal by all, but by some in one sense, by some in another. The freedom of his criticism could not but provoke strong attack from his opponents. Of the controversy this Society can take no cognisance, but it must be remarked, as a mere matter of biography, that in his assault upon some modes of theological thought, to which the university once appeared unalterably given, Mr. Powell seems to have been as much of a precursor as in his efforts to stimulate science. The last of his writings appears as one of seven *Essays and Reviews*, most of his colleagues being Oxford men; and the whole of this work, which is in its fourth edition, shows that Oxford names of no mean note are now pledged to admit that freedom of examination which brought so much assault upon the isolated individual who first used it while actually connected with the university. Every meeting of educated men will contain those of the most opposite views as to his conclusions; but all will admire the fearless manner in which, without reference to his own interests, he spoke out the conclusions of his mind.

In the year 1850 Baden Powell was appointed one of the Government Committee of inquiry into the studies enjoined in Oxford; he being well known as an ardent educational reformer, a fact pretty well evinced in his tract on "State Education," considered with reference to "prevalent misconceptions on religious grounds." In 1854 he was selected, at Aberdeen, one of the three judges to award the valuable Theological Burnett Prizes in that city. Nor was the range of his capacity confined to argumentative studies only; for he not only possessed a large fund of general information, but was also a proficient in painting, and was well practised in the choral harmonies of church music, in which science he was a strong amateur.

The Professor's lamented death, on the 11th of last June, was the result of an attack on the lungs which commenced in the previous winter. He had been duly warned of his danger by his medical friends and attendants, several weeks before he expired; but he was resigned to the last, his only uneasiness being a difficulty of breathing, which, after a few days of extreme debility, terminated his existence. He died at his house in Stanhope Street, Hyde Park Gardens, at the age of 63, having scarcely ever been ill before. He was three times

married, and leaves a numerous family. His widow is the daughter of his and our colleague, Admiral Smyth.

Mr. Powell was for years on the Council of this Society, a regular attendant, and a zealous co-operator.

William Simms was born on Dec. 7th, 1793, at Birmingham, he was brought to London by his parents at a very early age, and when fourteen years old was apprenticed to Mr. Bennet, of Charles Street, Hatton Garden, one of the best "Chamber Masters" of that period, and who was originally a pupil of Ramsden.

Having served his time to the satisfaction of his master, and with credit to himself, he then commenced business as a mathematical instrument-maker at Bowman's Buildings, Aldersgate Street, in the City of London.

He was early connected with the Society of Arts, and became acquainted with several of its most eminent members, in consequence of the exhibition of a peculiar protractor of his own contrivance. This led to his introduction to the late Francis Baily, Esq., and Bryan Donkin, and through the latter to Col. Colby, then Superintendent of the Ordnance Survey.

Col. Colby was at that time in want of some large theodolites, and trusting to the representations of the friends of Mr. Simms as to his capabilities, was induced to give him an order. These instruments were completed so much to the satisfaction of the Colonel that other orders soon followed, and a large business speedily became the result.

Mr. Simms joined Troughton in 1826, and after a partnership of five years (Mr. Troughton retiring) carried on the business until his death.

He became a Fellow of the Royal Astronomical Society in 1831, and of the Royal Society in 1852.

He died at his residence at Carshalton on the 21st of June, 1860, and was buried in his family grave at Norwood Cemetery. The works of Mr. Simms are too numerous to be described here, most of them are well known, and accounts of some are to be found in the Memoirs of the Society.

By his connexion with Troughton Mr. Simms could not but acquire a well-known name; but it must be remembered that he was possessed of great skill and ability, and was not unworthy to be associated with his celebrated partner. The Cambridge Mural Circle, and the whole of the instrument-maker's part of the Greenwich Altazimuth, Transit-Circle, Reflex Zenith Tube, and Great Equatoreal, with many other instruments of repute, were the work of Mr. Simms. The admirable 8-inch object-glass of the Greenwich Transit-Circle also was ground by him. His improvements in the graduation of instruments were in some cases so much the work of time as to be hardly capable of being signalised as improvements at any one moment. By his self-acting dividing machine he

reduced the work of weeks to the work of hours, as well as improved the accuracy of the process, and contributed important aid to the distribution of well-divided instruments for the ordinary purposes of navigation and surveying. The Astronomer Royal, when engaged in the construction of the Greenwich Transit-Circle, after anxiously examining the various methods of graduating the Zenith-Distance-Circle, satisfied himself that it would be done most accurately by the use of Mr. Simms' dividing-machine; and the excellence of the result has proved the correctness of the decision.

Mr. Simms's character was remarkably one of fairness and candour. Persons who transacted much business with him, though they began with him in his character of tradesman, usually learnt to recognise him as a friend.

Mr. Simms was an active member of our Council at several different periods. His services were given in his own quiet and unpretending manner. His voice was little heard, but his colleagues knew that his sound judgment and hearty co-operation could be relied on.

The observations at the Royal Observatory, Greenwich, maintain that steadiness of character which has given to its publications so great a value. In the last summer the great Equatoreal was made efficient, but the absence of the Astronomer Royal for observation of the eclipse and other interruptions have prevented it from being brought into regular use. It has, however, been employed to a considerable extent in the preparation of delineations of *Jupiter* and *Mars*. The former of these planets has exhibited, in the last year, some appearances never before recorded; and it has appeared very desirable to register, as soon as possible, anything which seems to indicate a change in the constitution of that great body.

The time-communications of the Royal Observatory (of which the population of the British Isles is every day availing itself to an extent of which it is little aware) are now made by galvanic signals conveyed by open-air wires.

The Astronomer Royal retains the intention, as soon as the state of reductions shall permit, of preparing a 7-years' Catalogue of Stars from the observations made at the Royal Observatory from 1854 to 1860.

The printing of the *Greenwich Observations* for 1859 is finished in all important points. Some additions are contemplated, which will prevent its distribution for a short time.

Mr. Main has been succeeded, as First Assistant, by Mr. Edward James Stone, Fellow of Queen's College, Cambridge.

From the Royal Observatory, Edinburgh, we have a printed Report addressed to the Board of Visitors there, on the 24th of April, 1860; and have further accounts to the end of January 1861.

The printing of the past observations with transit instrument and mural circle has been in continuance, and has reached the end of 1858. The instruments themselves have had some subsidiary applications made to them, to promote the facility and precision of handling and using them for ordinary observations; and some of an extra character have been applied to the shutter openings of the transit instrument, as well as to the telescope itself, to fit it for a special series of measures, adapted to inquire into the supposed "Solar Refraction" of Prof. W. Thomson. This series commenced on the 1st of May, and for two or three days went on somewhat hopefully; but immediately thereafter began a cloudy season, which continued without any interruption during nearly the entire summer, and especially during the period of the larger stars in *Taurus* and *Leo* being near the Sun's place. Attention had been called in the printed report to the unequalled opportunity which the then approaching solar eclipse would give, to those who should be within the range of its totality, for observing stars situated favourably and effectively to develope the solar-refraction effect to a definite and tangible amount, should it really exist to the degree and in the manner anticipated. It is believed, however, that amongst the numerous and more certain phenomena which occupied the attention of the many able astronomers who witnessed the eclipse in Spain, the solar-refraction question did not form one of them; and hence it is left to future times to make, during the dark interval of another total eclipse, an observation pregnant (it may be) with important result on the physics of the Sun and the Solar System, simple and straightforward in itself, but which has never been made yet from the commencement of the world; viz., the measure of the distance of two stars, not more than two or three degrees apart, when the Sun is apparently between them. Although the Edinburgh Observer was unable to visit Spain, he had communicated with some who were more fortunate, and has since been assured that there is every reason to believe that a 6-inch object-glass would have been able to show stars of the 5th or 6th magnitude, at not further than half to three-fourths of a degree from the border of the Moon's disk when completely eclipsing the Sun.

The occultations of the *Pleiades* in September were duly observed at Edinburgh, in concert with the Americans; and by means of an electrical apparatus, which so intensified the seconds'-beats of the transit clock, as to enable them to be heard equally by the transit observer, and by the watcher of the occultations, in opposite parts of the building.

The electrical time-ball, daily worked by the Observatory, has given rise amongst the citizens of Edinburgh to a desire to have its visible manifestations supplemented by an audible signal, in the shape of a cannon in the Edinburgh Castle, to be fired by electrical signal from the Observatory. This desire

has not only manifested itself at the meetings of public commercial companies, but also in the collection of so large a subscription to pay for the expenses of the connecting wire, and the gunpowder, that Her Majesty's Government have been pleased to entertain the proposal to some extent, and experiments were lately made by the military in the Castle, as to the best size of gun, charge of powder, and general position.

The Edinburgh Observatory still carries on the reduction of meteorological observations from 55 stations in Scotland, for the Registrar-General's Department; and in the course of a special inquiry undertaken with regard to the circumstances and characteristics of a remarkable and destructive storm on October 3d, 1860, it has had the honour of receiving special communications of hourly or other frequent observations from the several establishments of Greenwich, Oxford, Glasgow, and Armagh; from the Imperial Observatory of Paris, with returns from several French stations; and similarly, from the Royal Observatory of Brussels, from the same of Christiana, Konigsberg, and Utrecht, from the Imperial Physical Observatory of St. Petersburg, and from Altona, Copenhagen, and Iceland.

The ultimate reputation of an Astronomer in a public Observatory rests in part upon his successor, upon whom depends the manner in which his growing crops are brought to maturity. The appointment of the Rev. R. Main, in June last, to the Radcliffe Observatory at Oxford will secure to our lamented late colleague, Mr. Johnson, the full credit due to his acknowledged skill and industry. This appointment has given high satisfaction to the astronomical world; the subject of it being their own President, the Council will say no more. During the interval between the death of Mr. Johnson, in March 1859, and this appointment, the Observatory was in charge of Mr. Quirling, the First Assistant, and meridian observations of stars were made with the transit instrument and the meridian circle to as great an extent as his own unassisted strength permitted. The meteorological observations were carried on without interruption during this period by Mr. Green. The printing of the Radcliffe Catalogue of Stars was also completed. This important work is noticed in another part of the present Report.

On Mr. Main's assuming the direction of the Observatory his first care was to provide for the publication of the Radcliffe Catalogue, and the examination and revision which were necessary occupied him for some time. The next point of importance was to put the Heliometer into a state fit for observing. Its general condition was very satisfactory, but the telescope was found to work so stiffly in its collars that it would have been impracticable to use it with effect for measuring angular distances, and, there being no provision for *illumination* of the field, it could not be used as an ordinary

equatoreal instrument. This defect of stiffness having been remedied, the telescope-tube was also perforated near the eye-end, and a ring-reflector was inserted for throwing light down the telescope by means of a small lamp, and by this means good illumination is obtained. The only circumstance to be regretted is that, by the taking out of the object-glass, some small disturbance has taken place in the relative position of the halves, so that at the zero, when the images ought to cover each other they are again separated by a small interval. This defect will be removed on the first opportunity, and the instrument will be then in a thoroughly satisfactory state.

The meridian instruments are employed chiefly for the completion of the observation of Mr. Johnson's "Catalogue of Remarkable Objects," and Mr. Main proposes to commence shortly the compilation of another Star Catalogue, which shall include the places of all the stars which have been observed from the year 1854 to 1861, both inclusive. He proposes also to employ the heliometer for the observations of the larger planets, and for observation of a catalogue of Double Stars.

While thus passing in retrospect the now concluded labours of the late Mr. Johnson, the Council take this opportunity of making some remarks which they think worthy the notice of those who are members of the governing bodies of our public Astronomical Institutions. They are aware that questions of policy in regard to expenditure arise from time to time, and are decided on their apparent merits at the time, and that trustees may often wisely hesitate to follow every recommendation to supply new and expensive instruments. In a manufactory, a Principal, while certainly not adopting all the promising schemes which patentees are too ready to put before him, will take care as early as his means permit, to introduce any new and improved machinery whereby better and increased production may be profitably secured. In an Observatory where profit is not the motive, but economy and improvement should be, it is equally bad policy to retain old instruments too long, when the introduction of new ones would enable the Astronomer and his staff to do in one year the work of three with the old. It is to be remembered also, that when by defect of instrumental arrangement or deficiency of computing power, a limited work is thrown over a needlessly long term of years, the risk of the Astronomer's labours being left incomplete by his death, and perhaps never made available at all, is also greatly increased. Mr. Johnson's life was fortunately continued sufficiently for his work to have escaped all but the final risk of injudicious publication, and this has been avoided by the care and interest of our President. Another instance has lately occurred in which our science has had better fortune than was apparently insured by the arrangements of foresight. The recently published Armagh Catalogue is the

summary of so protracted a series of observations that the happy result can only be regarded with the feeling of those who have escaped shipwreck. With good organisation and a good transit circle, such as Groombridge had, the work of revising the Catalogue of Groombridge might certainly (judging by the Redhill Catalogue of Mr. Carrington) have been performed within five years; and if this view be correct, it is clear that the possession of such an instrument would have left years of Mr. Johnson's life free for the attainment of still further results. It is part of the self-constituted duty of a deliberative body, such as the Council of this Society, to point out with respect, but still with candour and completeness, any course which sound policy may recommend for the prosecution of astronomy. The Astronomer Royal once calculated the cost to the country of one complete observation of the Moon in both elements, including rental of premises or the equivalent, wear and tear of instruments on a series of years, share of salaries, printing and incidental expenses, and we believe he made it about 10*l.* We do not often dwell on the cost of our productions, but it is desirable that the costliness in mere money should not be lost sight of, whether the country supply the funds or there be an endowment of private origin concerned. We should much like to see a competent examination, with the cost per thousand of concluded positions of stars (with due regard to the degree of accuracy attained) for different establishments, and have little doubt that at the head of the list of economical production would stand Bessel's Zone-observations. The admirable work now in hand by Dr. Argelander, though designedly of another order of execution, calls for notice in this respect, but would lead our intended remarks beyond the object in view.

The ordinary work of the Cambridge Observatory is described in the usual Report of the Observatory Syndicate. Shortly after the date of the Report (May, 1860) Mr. Challis succeeded in engaging a second computer, who, as well as the first, is paid from the proceeds of the Sheepshanks Fund. With the aid of his two assistants and the two computers, he made great progress in the latter half of last year in the reduction of the meridian observations of past years, which was advanced completely to the end of 1857. The meridian observations of the three last years, which were comparatively few, are now occupying attention. The observations of late have been of a miscellaneous character, and the number of the regular meridional and equatoreal observations has been much diminished. Since May of last year, meridian observations have been resumed solely for the purpose of determining the places of comparison stars. Some good micrometer measures of the solar eclipse of July 18 were obtained, and the scrutiny of the Sun's disk for detecting intramercu-

rial planets has been continued, but without success. Last summer, as during several previous years, the corrections required for the effect of the forms of the transit pivots on the times of meridian passage were ascertained. The conclusion arrived at is, that unless this source of error be continually guarded against, determinations of differences of longitude cannot be depended upon.

Professor Challis completed, in the summer, a second series of measures with collimators moveable about the Mural Circle, for the purpose of ascertaining the effect of flexure on the circle readings; and the result obtained was, that six microscopes almost entirely eliminate errors of reading due to flexure of the material, care being taken to have a uniform temperature in all parts of the circle room. The discordance of zenith points exhibited in direct and reflected observations with the large Circle is to an amount which flexure of the material will not account for.

The Sheepshanks Fund has hitherto only been devoted to paying computers, and that to a moderate amount, so that the proceeds are accumulating. What Professor Challis has recommended is, to employ the reserve fund, when of sufficient amount, in purchasing a new Transit-Circle, which this Observatory stands much in need of; neither the transit nor the mural circle being now as good and efficient as the present state of astronomical science requires.

Professor Challis has laid before the Council of the Senate a formal request to be relieved from the duties of the Observatory, retaining the Professorship. A syndicate has been appointed to consider the matter, and report in the course of this term. His reason for making the request is, that he has been actively engaged as a practical astronomer for twenty-five years, and thinks he will do well to retire from this kind of duty before he is unable to discharge it, and while he is capable of astronomical and scientific work demanding less bodily exertion, and in great measure arising out of the practical work which he has done at this Observatory. Under these circumstances, it is to be hoped that Professor Challis will remain in fact, though not in name, closely connected with the Observatory which he has so long and so ably conducted.

Vol. xix. of the *Cambridge Observations*, containing the meridian observations of 1852, 1853, and 1854, is not yet published, a few sheets of the Introduction remaining to be printed. The delay has been caused by its being necessary to insert a great deal of fresh matter into the Introduction, in order to describe fully new apparatus and new modes of observing adopted in the course of those years.

Professor Grant obtained definitive control of the Glasgow Observatory in the month of May last year. The principal

instrument of the establishment is a meridian circle of $3\frac{1}{2}$ feet diameter, by Ertel of Munich, with which a course of observations has been commenced. A portion of the results, consisting of observations of the Minor Planets, has been recently forwarded to Professor Peters for insertion in the *Astronomische Nachrichten.* Meteorological observations continue to be made nearly on the plan hitherto pursued. Steps have been taken for establishing an electric communication between the Observatory and the central parts of the city, with the view of transmitting correct Greenwich time from the Observatory, by the method which Mr. Hartnup has practised so successfully at Liverpool.

At the Liverpool Observatory Mr. Hartnup has been engaged in alterations, now nearly completed, which have been progressing during the past nine months. A new chronometer-room, library and computing-room, have been added to the establishment. In the former, every possible care has been taken to render it as perfect as practicable for testing and ascertaining the rates of chronometers in different temperatures. This room, which is eighteen feet by twenty-eight, has a large double skylight, and the walls, which are very thick, have a cavity between them. The room can be warmed by hot-water pipes, which are carried under the floor, but this will not often be required, as there are in the room two warm-air chambers which will hold upwards of one hundred chronometers each. The tops of these warm-air chambers are made of plate-glass, so that the chronometers standing in their boxes, with the lids open, may be compared as frequently as desirable, and their rates in different temperatures ascertained without moving them from one place to another. The heating is all by gas, the pressure of which is regulated by a governor. The arrangements are so perfect that Mr. Hartnup hopes soon to see the rates of the chronometers, deposited at the Observatory by makers for the purpose of showing the perfection of their performance, published at regular intervals. The rates in different temperatures supplied to mariners will also be much more perfect than it was possible to obtain with the old arrangements.

The performance of the large clock at the Victoria Tower, which is controlled by Mr. Jones' method, has been very satisfactory. The striking of this large clock is quite simultaneous with that of the Liverpool Town Hall, which is also controlled in the same way, and at 1 P.M. they may be seen to be coincident with the dropping of the time-balls. The dropping of the Victoria Tower time-ball, by a mechanical arrangement with the distant clock, which is controlled by the Observatory normal clock, has been found to answer perfectly, no error having arisen from want of battery power or from any irregularity in the passage of the galvanic current.

The general routine duties of the Observatory have been carried on much in the same way as in former years, but the extensive alterations above named have prevented Mr. Hartnup from doing much with the Equatoreal.

The great activity of the Sun in producing spots during the year 1860 has restricted the attention of Mr. Carrington and his assistant almost entirely to their observation and treatment. The past year has been one of maximum action; and it may give some notion of the constant pressure of the subject on the observer, when it is stated that, of the stock of about 5000 accurately reduced positions, accumulated by Mr. Carrington since the beginning of the year 1854; 1893, or nearly two-fifths, are the produce of the past year. Much of this is attributable to the interest and assiduity of Mr. von Bose, by whom the greater part of the actual labour was performed. Mr. Carrington greatly regrets that at the close of the year Mr. von Bose was obliged to leave him, in order to resume the profession of chemistry, for which he retained a preference; and he cannot expect easily to meet with another assistant equally valuable to him.

It may appear to some that in thus largely observing in this field, an unreasoning instinct for the accumulation of any sort of observations is exhibited; but Mr. Carrington is deliberately following out a plan laid down at the commencement, of subjecting this phenomenon to severe record throughout one complete period, and it will be the fault of circumstances beyond his control, if this record should be interrupted before the next minimum is past. A sound basis of thorough observation has never before been laid in this department of astronomy, from which replies might be obtained to many hypothetical questions as well as to others suggested by the indications of the observations themselves. Reductions to place on the Sun have kept pace with the record, the whole of the observations of the past year being already worked out. Further discussion of these places will be pursued as his leisure permits.

Mr. Carrington called the attention of the Society in the month of May last to a first draft of the periodic variations of frequency for the past 120 years, concluded from the researches of Prof. Wolf into old documents mostly in MSS., and he would now again call attention to the last communication of his indefatigable co-labourer, wherein he has given his concluded relative numbers for this period of years, expressed in the same unit. The curve formed by laying down these numbers offers as interesting a problem for solution as any that has been laid before astronomical inquirers.

Mr. Lassell informs the Council that the two lithographs sent to the Society are almost the only fruits of the 4-foot Equa-

toreal. The anomalous weather, remarked by everybody, has made the instrument hitherto comparatively useless. He has been occupied in grinding and polishing a second, or reserve speculum, B, which is now in the tube, and is, he believes, fully equal in form of curvature to A, perhaps superior to it; for a little falling off of perfection towards the edge in A he does not detect in B.

But he has waited hitherto in vain for such a quality of sky as would enable him to determine the real amount of superiority of efficiency of this telescope over the 2-foot Equatoreal, whether it approaches its theoretical ratio of two to one.

At the Hartwell Observatory, since the 1st of January, 1859, till his sudden appointment, last October, to the Madras Observatory, on the recommendation of the Astronomer Royal, Mr. Pogson has been assiduously carrying on his researches on variable stars, and taking advantage of every opportunity for completing the sidereal charts connecting those of Berlin and Regent's Park. The Variable-Star Atlas is to be completed at Madras, with the express permission of Government.

Mr. De La Rue states that in his own Observatory at Cranford he has, during the past year, pursued photographic observations as continuously as the very unfavourable weather would permit.

Considerable improvements have been made in the driving machinery of his telescope, which leave but little to desire; and, as a necessary consequence, very fine lunar photographs have been procured. During the year whole constellations have been photographed by him: as two extremes, may be cited the *Pleiades* on the one hand, and *Orion* on the other. Since his return from Spain he has engaged Mr. Reynolds, one of his assistants during the eclipse, with the object of prosecuting celestial photography without interruption, should the weather, which has hitherto been very unpropitious, permit.

Among the works for the present and future years may be mentioned the following: the photography of the Sun's spots on a scale sufficiently large to admit of the study of the changes which they undergo from time to time; in view of which it is proposed to make these photographs on the scale of five feet to seven feet for the Sun's diameter; the exact determination of the libration, and of the diameters, polar and equatorial, of our satellite.

The work of the Kew photoheliograph has been considerably interfered with by the preparations for the trip to Spain, which necessitated various additions to the instrument; and since the return of the expedition Mr. Beckley's other avocations, together with the badness of the season, have prevented its employment on as many occasions as could be desired.

In consequence of the press of meteorological work now performed at Kew, the committee find it difficult to make adequate arrangements for the systematic continuance of the work of the photoheliograph, and it has been proposed to Mr. De La Rue to take charge of the working of the instrument at his own Observatory.

It is almost unnecessary to recall the attention of the Society to the phenomena and observations of the important total Eclipse of the Sun of 1860, July 18. Never before has the totality of an eclipse been observed by so many persons, nor probably ever through such an extent of country. In the year 1842 we believe that only two persons (the late Francis Baily and the present Astronomer Royal) made journeys out of England expressly for the purpose of seeing the total eclipse. In 1860 about forty observers went from England to Spain for that observation. From Scandinavia to Italy, astronomers, official and private, converged to the northern provinces of Spain; the French Government equipped an admirable and well-arranged expedition to Spain, at the same time providing for observations in Algeria; and the services of the British Government, in the appropriation to the use of astronomers, of the magnificent steam-ship the Himalaya, and in the making every conceivable provision for their wants and their comforts, will not be soon forgotten. The United States of America did not omit to establish temporary observatories at some of the most important points on the new continent; and finally (though first in absolute time) the totality was perfectly observed and carefully depicted by a British officer in the neighbourhood of Vancouver's Island, where the elevation of the Sun above the horizon was less than three degrees. Most of the foreign observers, and some of the English, have published their accounts, in different degrees of detail. But it has been found impossible hitherto to sufficiently examine, with a view to digest, the vast mass of accounts, principally from the Himalaya Expedition, which have come into the hands of the Astronomer Royal.

The part which photography has played in some of these observations will be presently referred to.

At places beyond the band of total obscurity the eclipse has been carefully observed. At our National Observatory, an extensive series of transit-observations and micrometer-observations was arranged, with the view of furnishing materials for ascertaining the errors, at that time, of all the tabular elements involved in the computation of the eclipse.

During the past year photography has proved itself of great value in exact astronomy. The solar eclipse of July 1860 afforded an excellent opportunity for testing the value of this method of recording phenomena, the duration of which is

so short as to defy all attempts of the most able observers to register them with precision by optical means, however much a preconcerted division of labour may reduce the amount of work to be done by each individual observer. Of the various problems remaining to be solved by observations of the total eclipse of the Sun in July last, the most interesting, perhaps, was the determination of the precise nature of the so-called red prominences, which were first seen in the solar eclipse of the year 1842. Fortunately, two photographic records, at two stations nearly 240 English miles apart and with instruments of a different character, have so confirmed each other as to place beyond all doubt the real existence of these phenomena. Mr. Warren De La Rue, operating with the Kew photoheliograph at Rivabellosa, near Miranda del Ebro (about lat. $42^\circ 42'\cdot5$ N., long. $11^m 42^s$ W. 17 miles, towards the *north*, from the central line), and M. Aguilar, associated with Father Secchi, employing the Cauchoix telescope belonging to the Observatory of the Collegio Romano, at Desierto de las Palmas (about lat. $40^\circ 4'\cdot4$ N., long. $0^m 1^s\cdot6$ W. $4\frac{1}{2}$ miles, towards the *south*, from the central line), have obtained photographic representations of the different phases of the eclipse, including the totality.

These records of the appearances during the totality are quite concordant *inter se*, and one with the other, and show, incontestably, that the Moon gradually covered and uncovered luminous prominences which retained a fixed position with respect to the Sun. It thus appears impossible to doubt but that they are real appendages of the Sun; without, however, denying that their appearance may be altered by refraction at the Moon's surface. The popular results of these photographic observations have already been made public through the newspapers and scientific journals, but the subsequent discussion of the facts recorded has served to render still more manifest the great value of these photographic results.

Mr. De La Rue's photographs during the totality were two in number, but these two afford four epochs for the determination of exact numerical data. M. Aguilar's photographs of the totality, which measure 9-10ths inch in diameter, were four in number, but are wanting in that precision of details apparent in those of the former gentleman, which measure four inches in diameter. Mr. De La Rue procured by his well-arranged plans 31 photographs of the other phases of the eclipse, and has given to the Society, at two of its meetings, a *vivâ voce* statement of the measurements of the photographs, and of the results they establish. These results may be thus briefly stated: — The photographs having been advantageously enlarged, for purposes of observation, to 9 inches and 13 inches in diameter, measurements of the lunar and solar diameters give data, in regard to the ratios which they bear to each other, almost absolutely in accordance with theory; moreover,

with respect to the Sun, his equatoreal diameter is found to be measurably greater than his polar diameter. Measurements of the chord and of the versed sines of the cusps of the Sun and Moon give accordant results in regard to the angles of position of the line of centres of the Sun and Moon, and of their respective diameters; and, consequently, the distance of the Sun and Moon centres at the epoch of each photograph. With these data, the direction of motion of the Moon's centre, and the nearest approach of the lunar and solar centres, are determinable with great accuracy. Having found the relative positions of the centres of the Sun and Moon, Mr. De La Rue has etched upon an enlarged photograph on glass of the Sun, 9 inches in diameter, the luminous prominences seen on the first and second of the totality photographs, and has thus referred them to the Sun's centre, with great precision. Copies of the first photograph of the totality, superposed on the second, coincide absolutely in respect of those prominences visible in common at both epochs, and on both the first and second photographs can be traced the extent and direction of the Moon's motion.

The movement of the Moon apparent on each individual photograph, and the extent of movement evidenced by a comparison of the two photographs, are in strict unison with the demands of theory. One unexpected result of the use of photography in this case was, that it rendered evident the presence of certain prominences which, on account of their being not more luminous than the surrounding corona, did not impress the eye, but which, from the fact of their being of different actinic power, were nevertheless detected by the sensitive plate. Another remarkable and unlooked-for fact in connexion with these observations was, the great brilliancy, optically and actinically, of the luminous prominences and corona. The Kew photoheliograph, in which the focal image is magnified eight times, and its intensity consequently diminished fully 64 times, gave an impression of the luminous prominences in 20 seconds, and of the corona in one minute; whereas it did not give the slightest trace of the image of the Moon at full in one minute; and in the Cauchoix telescope the unmagnified focal image of the corona was well imprinted in 20 seconds.

The Council have to notice an error in the Annual Report for 1859, February 11. In the account of discoveries of small planets, *Calypso* (53) is attributed to M. Goldschmidt. As noticed, p. 166 of vol. xviii., it was, in fact, discovered by Dr. Luther, at Bilk.

During the twelve months which have elapsed since our last anniversary, five new bodies have been added to the group of Minor Planets revolving between *Mars* and *Jupiter*. The first (*Concordia*) was discovered on the 24th of March at Bilk

by M. Luther. The second (unnamed) was discovered on the 12th of September, at Paris, by M. Chacornac. The third (*Danaë*) was discovered on the 9th of September, at Paris, by M. Goldschmidt. The fourth (*Titania*) was discovered on the 14th of September at Washington, by Mr. Ferguson. The fifth (*Erato*) was discovered on the 14th of September, at Berlin, by Dr. Förster and M. Lesser, who determined its position under the impression of its being identical with the planet discovered on the 10th of the same month by M. Chacornac. Its existence as a distinct planet was established in the course of the following month. The total number of bodies constituting the group of Minor Planets now amounts to sixty-two.*

The list of Comets has been enriched by the discovery of four new bodies of this class in the course of the past year. The first was discovered on the 26th of February, at Olinda, in Brazil, by M. Liais, who saw it only on three subsequent nights, the presence of moonlight having prevented further observations of it. From its extreme southern position it was invisible in Europe. The observed places have been satisfactorily represented by a parabolic orbit. This comet exhibited the interesting phenomenon of two distinct heads.

The second comet was discovered on the 17th of April, at Hamburgh, by Mr. George Rümker. It was a faint telescopic object, and continued visible only during a short time. The elements of the orbit have been found to be sensibly parabolic.

The third comet was first seen on the 20th of June, at Utrecht, by M. Gronemann, and on the same day by Prof. Caswell, on the deck of the steamship Arabia, while on his voyage to England. When it attained its greatest brilliancy it was visible to the naked eye, and formed a conspicuous object in southern latitudes, where it continued to be observed till towards the end of August. M. Liais has found that the observations would be best represented by an elliptic orbit, with a period of about 1089 years.

The fourth comet was discovered on the 23d of October, at Marseilles, by M. Tempel. The observations of it consist solely of two places determined by the discoverer, and one by M. Villarceau at Paris, moonlight having soon rendered it invisible. From these observations a parabolic orbit has been calculated by M. Valz, who remarks that the elements bear some resemblance to those of a comet discovered by Pons in 1822.

The Council are happy in being able to announce, in their

* Since the date of the Meeting a sixty-third Minor Planet has been discovered by M. de Gasparis: see the conclusion of the present Number. —Ed.

Annual Report, the publication of the Radcliffe Catalogue of Circumpolar Stars. The delay in the appearance of this great work, the result of Mr. Johnson's star-observing for fourteen years, was caused solely by the temporary interregnum at the Observatory after his death, as the printing of it (with the exception of the Introduction) was completed in the summer of 1859. Copies were, however, most liberally distributed by the authority of the Trustees on its publication in December last, to the various institutions and individuals in every part of the world, who have an interest in astronomy, and there is no doubt that it will not disappoint the expectations of astronomers. It gives the accurate places of 6317 stars; most of them circumpolar in this latitude, the greater part of which are determined by not fewer than three observations in each element, while those stars included in Groombridge's catalogue of circumpolars, have been observed at least five times. The bringing up of Groombridge's places to the epoch of the Radcliffe Catalogue, and the comparison of the results, though it added considerably to the labour of the computation, forms a most useful part of the work, because, by this means, the proper motions of all these stars, amounting to 4243, have been virtually determined, and a basis is laid on a large scale for speculations in such branches of sidereal astronomy as depend on the proper motions of the stars. Amongst the subjects for congratulation in the active progress of various branches of Astronomy during the past year, the publication of this valuable catalogue must be reckoned among the greatest.

Among the astronomical works which have appeared during the last year, probably the greatest and most important is the *Theory of the Moon's Motion*, by M. Delaunay. Of this great work, which has been eagerly expected by astronomers, the first volume was presented to the Academy of Sciences by M. Delaunay at the meeting of December 24 last, and it forms the twenty-eighth volume of the Memoirs of the Academy. By the various discussions which have recently taken place concerning the lunar theory, and particularly by the controversies of its most distinguished investigators, the members of this Society have been made acquainted both with the magnitude and the enormous labour of the work in question, and also with the peculiarities of the method employed by its author, as far as he himself had given explanations in his various papers which appeared from time to time in the *Comptes Rendus* of the Academy. But the published work gives information on both these points which could not have been anticipated. With regard, for instance, to the labour expended upon it, it is sufficient to say that the development of the disturbing function was effected by means of 57 operations, and that the number of periodical terms in it is 461, occupying 138 pages of the printed work. In his preface M. Delaunay gives a very clear

account of the various processes which have been employed in effecting the developments in the lunar theory since the time of La Place, and of his means for pursuing his coefficients to the end of the work in their literal form, this being one of the chief points of difference of opinion between himself and M. Hansen. The peculiarities of his process are best given in his own words:—"In conformity with the excellent Memoir of Poisson of 1833," he says, "I have taken for my point of departure the differential equations furnished by the theory of the variation of arbitrary constants, and I have adopted a system of elliptic elements such that these equations may have the most simple form of which they are susceptible. The perturbing function, of which the partial derivatives, relative to the elliptic elements, furnish precisely the value of the derivatives of these same elements with respect to the time, may be easily developed in a series of periodical terms. If we did not take care, the introduction of this periodical series into the differential equations would be attended by a serious inconvenience: the time would result from terms involving sines and cosines, which would be a considerable check upon the employment of these differential equations for the determination of the lunar inequalities. I get rid of this inconvenience by a very simple method, which differs essentially from those employed before me for the attainment of the same end, and which has the great advantage of leaving to the differential equations the form which they had at first. As to the perturbing function, it is found by this means modified in such a way that the time no longer enters into it implicitly, excepting as it is introduced by the values of the co-ordinates of the disturbing bodies, and, in addition, a certain non-periodical term independent of the perturbing actions of these bodies. This being done, I suppress from the perturbing function the totality of the periodical terms which it contains, with the exception of one only, which I choose amongst those which have most influence in producing inequalities. In introducing this function, thus simplified, into the different equations, I find that they are completely integrable. I then profit by this integration to deduce from it formulæ, the office of which is to replace the six variables which I had by six others of the same kind. When, by the use of these formulæ of transfer-matter, the new variables are substituted for the old ones in the perturbing function and in the expressions of the co-ordinates of the moon, it results, first, that one of the important terms of the perturbing function disappears (the periodical terms which at first had been alone retained); secondly, that different inequalities corresponding to this term are introduced into the values of the three co-ordinates of the Moon; and further, that the values of the six new variables in functions of the term are determined by differential equations of precisely the same form as those which determined the values of the six variables for

which they have been substituted. Thenceforward, the integration of the differential equation being brought to the same point as in the preceding case, excepting the disappearance of a periodical term in the perturbing function, a new operation analogous to that which has just been effected causes in the same way another term of this function to disappear; a third term may in the same way be taken away from it by means of a third analogous operation, and so on. In this manner, after there have been effected a sufficient number of operations of this kind, the perturbing function is found to be rid of its most important terms, and the problem is thus rendered simple enough to be treated in the same manner as if it were a question of the perturbations of a planet or of the Sun."

The author, after giving a summary of the published volume, states that the second volume will contain, 1st, the different formulæ the office of which is to take account of the terms which remain in the perturbing function after the fifty-seven preceding operations have been effected; 2dly, the expressions of the three co-ordinates of the moon, with *all* their inequalities to the seventh order inclusively for the longitude and latitude, and to the fifth order for the reciprocal of the radius-vector; 3dly, various chapters intended to complete these expressions of the co-ordinates of the Moon, by taking account of everything which had provisionally been put on one side for the purpose of having to consider only the capital portion of the problem.

Such is a brief account of perhaps one of the most laborious analytical works ever accomplished by a single individual unaided. For fourteen years the author has been working without the assistance of a single computer, and uncheered by anything but his own clear views of his theory, and his consequent conviction that the result, when accomplished, would be worthy of the pains bestowed upon it. We may congratulate not only this Society, but the civilised world, on having at length before it this imperishable monument of combined human industry and talent; and at the same time offer also our congratulations to M. Delaunay that he has at length seen the end of his severe labour, and is now reaping the fruits of it in the intrinsic value of the work, and in the respectful admiration of contemporary astronomers.

During the past year has been published a new Catalogue of the Library of the Pulkowa Observatory, by M. Otto Struve. Though the titles are briefly given, they fully serve to identify; and this publication is very valuable. Great pains must have been taken to form this collection. The difficulty of forming a tolerably complete collection of known works—that is, already described by bibliographers—can only be matched by the facility with which a collection may be made of works which bibliographers have *not* enrolled. Lalande, whose bibliography

has not been surpassed in extent, has in his list works of the 15th, 16th, and 17th centuries, to the number of 2193. Of these the Pulkowa library possesses 973 works, or one out of three. Nevertheless, this same library could add one out of three to Lalande's list; for it possesses 905 works of the three centuries in question, of which Lalande knew nothing. It says something for the biographical utility of our Society that there are five *foreign* astronomers of whom no biographical accounts have found their way to Pulkowa except those in our *Monthly Notices.*

It will be in the recollection of the Fellows of the Society that, after a notice by the Astronomer Royal of the fitness, in different parts of the earth, of the summers of 1860 and 1862 for observations of *Mars* with a view to determine his parallax, an ephemeris of *Mars* and a catalogue of comparison-stars, illustrated by an engraved chart, were circulated by the Society, for facilitating the required observations. The proposal, however, failed totally. The northern observers, both in Europe and in America, were all so much interested in the observation of the total Eclipse of the Sun as to be unable to undertake the observations of *Mars*, and, even if astronomical engagements had permitted it, the bad weather and the southern declination of *Mars* would have greatly diminished the opportunities of observation. At the Observatory of Madras, the Observer (Major Tennant) judged the mounting of his Equatoreal (in the German form) to be too unstable to give trustworthy results; and at the Cape of Good Hope, the Observer, we believe, was distracted with other occupations. The Society will doubtless be anxious that every effort should be made to apply this method effectually at the ensuing opposition of *Mars* in 1862.

The Astronomer Royal, in his remarks upon the means at our disposal during the next few years for determining the amount of solar parallax, adverted to the importance of new tables of the planet *Venus*. Our illustrious associate, M. Le Verrier, has recently supplied this desideratum in so complete a manner as to leave little or nothing to be desired. His theory of the planet, which is almost wholly founded on the observations taken at the Royal Observatory, Greenwich, since the time of Bradley, with the Tables themselves, will form a part of vol. vi. of the *Annales de l'Observatoire Impérial de Paris;* but an outline of the principal results of M. Le Verrier's theoretical investigation appeared in the *Comptes Rendus* for 1860, Nov. 26. Its most remarkable feature is the confirmation it gives to a former inference of M. Le Verrier's, when discussing the lunar equation in the Earth's longitude, viz., that the received value of the Earth's mass is too small by a *tenth* part, and therefore the solar parallax as determined (under

doubtful circumstances) from the transits of *Venus* in the eighteenth century, will require a notable augmentation. On this subject the author observes that in consideration of its serious importance and delicacy, he contents himself at present with having added to the data previously in our possession for resolving the problem of the determination of the planetary masses, and before drawing a definite conclusion will await the completion of the theory of *Mars* upon which he is now engaged, and which will afford a third determination of the value of the Earth's mass. It must be admitted that M. Le Verrier's elaborate researches have added greatly to the interest always attaching to the question of the amount of solar parallax. M. Le Verrier having had the courtesy to forward copies of the tables of *Venus* to the Superintendent of the *Nautical Almanac* in anticipation of the time of their issue to the public, the ephemeris in the forthcoming volume for 1865 will be founded upon them.

Papers read before the Society from February 1860 *to February* 1861.

1860.

Mar. 9. On the Luminous Intensity of the Centre of the Sun. M. Chacornac.

Ephemeris of Variable Stars for 1860. Mr. Pogson.

On a Mode of getting rid of Personal Equation. Col. Shortrede.

Notes on Auroral Phenomena. Lieut. Chimmo.

On Phenomena connected with a Transit of *Jupiter's* third Satellite. Mr. Prince.

Star Occultations and Lunar Eclipse observed at Hartwell. Mr. Pogson.

On some previous Transits of Dark Bodies over the Sun. Mr. Carrington.

Proposed new Design for Vertically Placed Transit Circles. Mr. Carrington.

Note on an Eye-piece. Mr. Carrington.

Formulæ for the Reduction of Pastorf's Solar Observations. Mr. Carrington.

Extract of a Letter to Mr. Carrington. M. D'Abbadie.

On Future Observations of *Vulcan*. M. Radau.

On the Heat engendered by the Fall of a Meteor into the Sun. Mr. Waterston.

On the Variability of the Proper Motion of *Sirius*. Rev. R. Main.

Occultations of Stars by the Moon. Mr. Airy.

Mar. 9. Tables of the Developments of Functions in the Theory of Elliptic Motion. Mr. Cayley.

Occultations of Stars by the Moon. Mr. Burr.

Morning Illumination of the Lunar Crater *Hippalus.* Mr. Birt.

On the Total Solar Eclipse, July 18, 1860. Mr. Airy.

April 13. Observations of Small Planets. Mr. Airy.

Observations of *Hygeia* and *Urania.* M. Lepissier.

On an Appearance in *Jupiter.* Mr. Long.

On the Performance of Mr. Fletcher's new Equatoreal. Capt. Jacob.

On the Parallax of *α Herculis.* Capt. Jacob.

On the Appearance of *Jupiter's* third Satellite on its Disk. Capt. Noble.

Extract of a Letter to Mr. Carrington. Lieut. Gilliss.

Note on one of the Companions of *σ Orionis.* Rev. T. W. Webb.

Suggestions for a true Estimate and Register of the Colour of the Stars, &c. M. Drach.

On the Projection of *Saturn* on the Dark Limb of the Moon. Rev. B. Powell.

On the Appearance of *Jupiter's* Satellites while Transiting the Disk of the Planet. Rev. W. R. Dawes.

On the Figure of the Earth. Capt. Clarke.

Observations of Minor Planets. Mr. Pogson.

Reply to various Objections which have been brought against his Theory of the Secular Variation of the Moon's Mean Motion. Mr. Adams.

Solar Spots in High Latitudes. Mr. Carrington.

On the Secular Variation of the Moon's Motion. Rev. R. Main.

On the Appearance of *Jupiter.* Mr. Airy.

On the Satellite of *Saturn* "*Mimas.*" Rev. W. R. Dawes.

May 11. Catalogue of Positions, &c. of 398 Double Stars. Lord Wrottesley.

On the Problem of the Rotation of a Solid Body. Mr. Cayley.

Note on Mr. Pollock's Communication, No. 29. Mr. Airy.

On the Lunar Acceleration. M. Delaunay.

Apparent R.A. of the Moon's Limb observed at Washington. Lieut. Maury.

Observations of Minor Planets. Mr. Airy.

Note on the Lunar Acceleration. M. Pontécoulant.

Observations of *Hyperion.* Mr. Lassell.

Note on some Variable Stars of unknown or uncertain Period. Mr. Pogson.

May 11. Observations of Minor Planets. Mr. Airy.
On the Value of the Constant of Aberration. Rev. R. Main.
Observations sur les Formules employées jusqu'à présent pour déterminer par la Théorie le Coefficient de l'Equation Séculaire du Moyen Mouvement de la Lune. M. de Pontécoulant.
On the supposed Variability of the closest Companion of *σ Orionis*. Rev. W. R. Dawes.
Morning Illumination of part of the *Mare Imbrium*. Mr. Birt.

June 8. Postscript to Reply to M. de Pontécoulant. Mr. Adams.
On Projection in Lunar Occultations. Rev. T. W. Webb.
Occultation of *Jupiter* by the Moon. Capt. Noble.
Observations of Donati's Comet. Sir T. Maclear.
Comparison of Burckhardt's and Hansen's Lunar Tables with Greenwich Observations from 1847 to 1858. Mr. Airy.
Notes of Errors in Mr. Baily's Tables and Formulæ. Mr. Farrell.
Occultation of *Jupiter* by the Moon. Mr. Gaunt.
On Ancient Assyrian Observations of *Venus*. Rev. Dr. Hinckes.
On the Importance of making Observations on Thermal Radiation during the coming Eclipse of the Sun. Prof. Thompson.
Occultation of *Jupiter* by the Moon. Mr. Airy.
Réponse aux Observations présentées par M. Adams sur différentes Objections élevées contre sa Théorie de l'Accélération du Moyen Mouvement de la Lune. M. de Pontécoulant.
Elemens de la Comète decouverte à Olinda le 26 Fevrier, 1860. M. Liais.
Occultation of *Jupiter* by the Moon. Mr. Burr.
On a Grey Stripe eastward of Lunar Crater *Geminus*. Mr. Birt.
Note on the History and present Condition of the Problem, "To find the Latitude by Observations of the Pole Star at any time." Mr. Riddle.

Nov. 9. Devéloppement de la Fonction Perturbatrice en Série. M. Kowalski.
Observations taken at Redhill on the 18th July, 1860. Mr. Carrington.
On the Lunar Theory. Sir John Lubbock.
Observations of a Comet made in Australia. Mr. Scott.
Observations of Comet III. 1860. Mr. Ellery.
Approximate Elements of Planet (59). Mr. Ellis.

Nov. 9. Observations of the Moon and Moon-culminating Stars at Victoria. Mr. Ellery.

Elements of Comet II. 1860. Mr. Seeling.

New Variable Star in *Ophiuchus*. Mr. Pogson.

Solar Eclipse, July 18, 1860. Mr. Morton.

Ditto ditto Capt. Noble.

Ditto ditto Mr. Burr.

Ditto ditto Mr. Chalmers.

Ditto dttto Mr. Prince.

Ditto ditto Mr. Stothard.

Ditto ditto Mr. Riddle.

Ditto ditto Rev. Geo. Fisher.

Ditto ditto Mr. Janson.

Ditto ditto Rev. W. R. Dawes.

Observations of a Comet. Mr. Stothard.

Ditto ditto Col. de Rottenburg.

Ditto ditto Mr. Clark.

Note accompanying Lithograph of Nebula. Mr. Lassell.

Observations of a Comet at Sea. Mr. Krabbe.

On the Duration of Twilight at Toulouse. Mr. Petit.

Sun-spot Observations connected with the late Solar Eclipse. Prof. Smyth.

Elements and Ephemeris of Planet (59). Mr. Ellis.

On the Magnitudes of the Asteroids. Mr. Pogson.

Changes in 808 *Messier*. Mr. Pogson.

Observations of Solar Eclipse, July 18, from Hudson's Bay. The Hudson's Bay Company.

On a Photograph of the Sun. Prof. Challis.

Solar Eclipse, July 18, 1860. Mr. Airy.

Dec. 14. On some Formulæ relating to the Variation of the Plane of a Planet's Orbit. Mr. Cayley.

Observations of Solar Spots, with Drawings. Rev. Mr. Howlett.

Solar Eclipse, July 18: Photographs taken in Spain. M. Aguilar.

Observations on Solar Spots and Temperature. Mr. Hockley.

On a Method of determining Longitude by means of Observations on the Moon's greatest Altitude. Mr. Spottiswoode.

On the Motion of the Solar System and Distribution of Perihelia of Comets in relation thereto. Mr. Carrington.

1861.

Jan. 11. Results of Meridional Observations of Small Planets. Mr. Airy.

Note sur les Inégalités Lunaires à longues Périodes dues à l'Action Perturbatrice de *Vénus*. M. Delaunay.

On three new Variable Stars. Mr. Baxendell.

Jan. 11. On the Revolutional Velocities and Distances of the Planets. Mr. Glennie.

Addition to Paper, No. 134, "On the Lunar Theory." Sir J. Lubbock.

List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

Her Majesty's Government.
The Lords Commissioners of the Admiralty.
The Secretary of State for India.
The Postmaster-General.
Committee of Council on Education.
Royal Society of London.
Royal Asiatic Society.
Royal Geographical Society.
Royal Society of Edinburgh.
Royal Dublin Society.
Royal Institution.
Geological Society.
Linnean Society.
Zoological Society.
Photographic Society.
Society of Arts.
British Association.
Art-Union of London.
Institute of Actuaries.
British Horological Institute.
The Radcliffe Trustees.
Literary and Philosophical Society, Manchester.
Literary and Philosophical Society, Liverpool.
United Service Institution.
Historic Society of Lancashire.
Royal Society of Tasmania.
The Public Library, Calcutta.
L'Académie Impériale des Sciences de l'Institut de France.
Le Dépôt Général de la Marine.
Le Bureau des Longitudes.
The Society at Cherbourg.
L'Académie des Sciences, Montpellier.
L'Académie des Sciences, Dijon.
Imperial Academy of Vienna.
Royal Academy at Berlin.
Royal Observatory at Munich.
The Society of Physics at Berlin,

Royal Academy of Sciences, Brussels.
Royal Observatory, Brussels.
The Society at Leipsig.
The University at Göttingen.
La Société de Physique, &c. Geneva.
The Academy of Sciences, Stockholm.
Royal Academy of Sciences, Amsterdam.
Society of Sciences, Batavia.
Royal Academy of Sciences, Copenhagen.
Imperial Academy, St. Petersburg.
Imperial Observatory, Poulkowa.
Observatory, Dorpat.
Observatory, San Fernando.
Royal Observatory, Madrid.
Musico Fisico, Florence.
The Institute, Bologna.
Royal Academy of Sciences at Turin.
Philosophical Institute of Victoria.
The Department of State, Washington.
American Philosophical Society.
American Academy of Arts and Sciences.
Smithsonian Institution.
Boston (U.S.) Library.
The Franklin Institute.
The Canadian Institution.
The Editor of the Athenæum.
The Editor of the Literary Gazette.
The Editor of the Critic.
The Editor of the Atalantis.
The Editor of the London Review.

M. Allé.
M. Aguilar.
Prof. A. D. Bache.
W. C. Bergen, Esq.
M. Béron.
M. Boquet.
J. C. Bloxam, Esq.
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Prof. A. Caswell.
E. H. Coleman, Esq.
C. O. Dayman, Esq.
M. Daussy.
Prof. De Morgan.
M. Döllen.
S. M. Drach, Esq.
Prof. Encke.
Col. Everest.
M. Fechner.
S. Fenwick, Esq.
Dr. Francis.
M. le Prof. Gautier.
Dr. B. A. Gould.
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Prof. Hansen.
Sir J. Herschel.
J. Herapath, Esq.
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M. Hornstein.
Mrs. Hannah Jackson.
M. Laugier.
Dr. Lee.
Prof. Von Littrow.
Mr. Maillard.
Mr. E. Mailly.
Com. Maury, U.S.N.
M. Mettenius.
M. Moesta.

M. L'Abbé Moigno.
W. H. Morley, Esq.
S. Newcomb, Esq.
D. D. Owen, Esq.
Dr. Peters.
M. Plana.
Prof. Plantamour.
Wm. Pole, Esq.
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Sig[a]. Scarpellini.
M. Schaub.
M. Schubert.
Prof. A. Secchi.
Capt. Shadwell, R.N.
Miss Sheepshanks.
Lt.-Col. Shortrede.
Prof. Silliman.
Admiral Smyth.
Prof. C. P. Smyth.
M. O. Von Struve.
J. Taylor, Esq.
C. Vignoles, Esq.
M. Wagner.
Dr. Weisse.
Mr. J. Williams.
M. Winnecke.
Dr. R. Wolf.
Jas. Yates, Esq.

Address delivered by the President, the Rev. Robert Main, on presenting the Gold Medal of the Society to M. Hermann Goldschmidt.

Gentlemen,—In the Report which has been read to you, you have been informed that the Gold Medal of the Society has been this year awarded by your Council to M. Hermann Goldschmidt, for his discoveries of thirteen small planets, and other astronomical works, and the duty devolves on me to explain to you the grounds of this award. This duty, though not necessarily an annual one, has become so in fact, on account of the activity with which the various branches of astronomy have been for many years cultivated, and the undeniable claims which some one or other of our members or associates has established by eminent services or contributions to the science. In fact, I find that since the year 1848 (memorable for our recognition of the eminent claims of no fewer than twelve astronomers, by the award of a Testimonial to each), there has not passed a single year in which the Gold Medal has not been awarded, and I am certain that few persons would be found at the present time who would venture to deny either the justice or the prudence of the award in each individual case.

And, on looking at the list of subjects, one is rather tempted to admire the profusion of talent and the amount of industry which are exhibited in the various works for which the Medal has been awarded, and at the mass of labour in every department of our science which has been thus brought under review before us, and, of necessity, analysed in our meeting-room. The memoirs which have been crowned by us relate in some

instances to the closet labours of the theoretical or the physical astronomer, and in others to the work of the practical observer. In one year we have to reward a brilliant discovery, the result of years of profound study and analytical investigations; in another, the patient labours of an amateur astronomer, who, at his own cost, has produced a copious and valuable catalogue of stars. Sometimes it is a literary work, as the *History of Physical Astronomy*, which has claimed the award; at others, the corrections of some of the most important astronomical elements by a skilful employment of high mathematical attainments on the results of observations.

But, amongst the claims based on discoveries, none have been more frequent of late years than those arising from the addition of new members of the solar system, especially in the remarkable group of planets which lie between the orbits of *Mars* and *Jupiter*. At the commencement of the year 1845, four only of these small bodies were known, and those had been discovered for nearly half a century without receiving any addition to their number: at the present time their number amounts to sixty-two.

In four instances already have the rewards of this Society been bestowed for discoveries of some of these small planets; and the claims are each year becoming greater, and to such an extent, as to demand an explanation why, when there have been and are still so many successful labourers in this field of research, we have selected one amongst them as particularly deserving of the Medal on the present occasion? To this it might be replied immediately, that M. Goldschmidt has laboured more successfully than his competitors, and that the addition of thirteen new members to the solar system is a fact so remarkable in itself and so honourable to him, as to place him beyond the reach of competition, and to give him so high a rank amongst the benefactors of science, as to make the bestowal of our Medal only a fitting mode of expression of our sense of his great merits.

And, indeed, this is strictly and literally true, and there is probably no single name amongst the astronomers who have distinguished themselves during the past twenty years which stands so high in the list of discoverers. But relative merit is, after all, not a ground for the award, and it will be necessary to go rather more deeply into the history of this branch of discovery before I can confidently appeal to your own judgments in corroboration of that of your Council in making this award.

Omitting the history of the first four of the small planets which were discovered at the beginning of this century, it will be necessary to recall to your recollection that the next discoverer was M. Hencke, of Driessen, who, in 1845, discovered *Astræa*, under circumstances as meritorious as are those which I shall have presently to point out to you in the discoveries

of M. Goldschmidt. To this discovery I attach very great weight, as regards the merit of the discoverer; and I would express my opinion that, by originating this branch of research in connexion with the Berlin maps, M. Hencke's claims are of a higher order than those of all who have successfully followed in his steps, and that, if your Council had not already recognised them by the bestowal of a reward, it would be, even at this distance of time, necessary to do so. It must, in fact, be remembered in connexion with those discoveries, that, after M. Hencke, there has been no novelty in the method of search employed. In the greater number of instances the Berlin maps have been employed; and the necessity of this mapping of the stars for facilitating future discoveries has reacted most advantageously on the progress of sidereal astronomy, and has been the chief cause of that accurate survey of the Northern heavens which is now all but perfect. As an honourable example of this kind of research, and of the clearness of view which led to it, I may mention Mr. Bishop's Ecliptic Charts, completed by Mr. Hind,—a work in itself most meritorious and useful, and rewarded at the time by several brilliant discoveries. Another great work of the same kind which must be mentioned is the series of Star-Catalogues of Mr. Cooper, in connexion with which we may mention the discovery of *Metis* by Mr. Graham.

Here, then, Gentlemen, we have at once a definite ground for the encouragement of this branch of discovery, in its intimate connexion with the advancement of sidereal astronomy; and I think we may venture to say, that any one who will undertake the labour of constructing a map of stars as low as the 10th magnitude, for a zone of the heavens of moderate extent not very far from the ecliptic, will, as a matter of course, be rewarded by planetary discoveries. The sweeping of the heavens for stars and the search for planets, if properly conducted, may form one and the same operation; and when we reward the results of such work, we may do so quite independently of any consideration of the value of the planetary discoveries in themselves, though, as I shall try to show, this consideration is also in itself of very great importance. On the other hand, the verification of existing maps, such as the Berlin charts, by frequent and laborious comparison with the heavens, even if the object be not the construction of a new map, is of itself highly important and meritorious, and has led to the rapid increase of discoveries in a branch of the science formerly but little studied, namely, that of variable stars. In these discoveries M. Goldschmidt has also taken a part. It is clear, therefore, that discoveries of small planets are so connected with the extension of other branches of astronomy, that they are in the highest degree deserving of encouragement; but it is equally clear that, in estimating the merit of such

work, our attention must not be fixed chiefly upon that which first attracts the applause of the uninstructed public — that is, upon the brilliancy of the discovery as such — but upon the amount of good and useful work well directed which it puts in evidence in connexion with sidereal astronomy.

Now, the work itself is of a nature to attract to it young astronomers of unbounded energy and zeal, as offering the best chance of success and distinction at an early period of life. The labour is severe, but the reward of perseverance is literally certain, and, as a consequence, a great number of competitors — thirteen, in fact — have won laurels in this field. This gives an average number of nearly five discoveries to each person; but, as usual, the rewards of labour have been very unequal, so that, while M. Goldschmidt has discovered thirteen planets, five of the aspirants have discovered only one each.

Next to M. Goldschmidt, the most successful have been Mr. Hind, M. R. Luther of Bilk, M. De Gasparis,* and M. Chacornac, who claim respectively ten, nine, seven, and six of the planets. Of others, Mr. Pogson has discovered three and Mr. Ferguson also three. M. Hencke discovered two, while Messrs. Graham, Laurent, Marth, Searle, and Forster, have each discovered one. The above statement, if we include the four more ancient small planets, accounts for the whole number, sixty-two, at present known.

The work, then, which M. Goldschmidt has accomplished is, in its cumulative aspect, a great work — greater, perhaps, than has yet fallen to the lot of any other observing astronomer. If we regard the discoveries individually, they are, as I have explained, not of that original or brilliant character which stamp some of the other great discoveries of this age; they are within the scope of most men of energy, who are gifted with sharp eyes, and capable of enduring the fatigue of long watching and examination of the heavens; but, conducted as they have been by M. Goldschmidt for eight years with scarcely any intermission, and resulting in the addition of so many new bodies to our known solar system, they are admirable, and rank their discoverer amongst the first observers of his age, and distinguish him as a man of whom France and Frenchmen may be proud.

Thus far, Gentlemen, I have abstained from saying anything of the means at the disposal of M. Goldschmidt for making these discoveries. I have allowed you to suppose, if you are not acquainted with his history, that he was at least upon a level in point of equipment with his rivals, some of whom (though not all) had the use of large telescopes in fixed observatories. Indeed, the apparent magnitudes of the planets

* The number discovered by M. De Gasparis is now eight.—Ed.

discovered would seem to make some such supposition necessary. For example, *Lutetia*, the planet first discovered by him in 1852, he estimated at the 9–10 magnitude; and I am sure it would not have occurred to any of us professional astronomers that such an object was likely to be looked for with success with any object-glass less than 4 or 5 inches. Well, Gentlemen, the telescope with which he made this discovery, by the help of the Berlin star-maps, was of 23 lines aperture, or rather more than 2 inches; such a telescope, in fact, as you see frequently at watering-places for observations of ships and sea-side objects, but such as was perhaps never before used for the discovery of a planet. But this telescope was one of which the young astronomer might well be proud. It, or a smaller one of 19 lines aperture, which it replaced, was purchased with the money obtained for one of two copies which he had made at Florence of the portrait of Galileo. Never, perhaps, were great results accomplished by so small means as were at his disposal; and if this be, as is generally believed, an attribute of genius, M. Goldschmidt may fairly claim the admiration which is due to it. A telescope of 2 inches aperture, placed in the window of a garret forming the sleeping apartment of the astronomer, is made, by judicious handling and severe scrutiny of the Berlin maps, to discover one of a class of objects which it taxes to the utmost the astronomers of Greenwich to observe, when found, with the great transit-circle. But better days were in store for the Astronomer. His next four discoveries—those, I mean, of *Pomona*, *Atalanta*, *Harmonia*, and *Daphne*—were made with a larger telescope; how obtained I am not able to tell you, excepting that it was certainly out of the fruits of his industry in his professional employment as an historical painter, and by the practice of the most rigid economy. Well, Gentlemen, this telescope, undoubtedly an improvement on the preceding, was of 30 lines, or 2⅝ inches aperture, and with this still apparently inadequate instrument did he discover four additional planets. The remaining eight were discovered with a telescope of 4 inches aperture, and I wish I were enabled to give you some information about its acquisition. Let it suffice that none of them were mounted equatoreally, but that, in the greater number of instances, they were pointed out of a window which did not command the whole of the sky; and I now leave you to form your own opinion of that fertility of invention and resource, that steady determination to conquer apparently insurmountable difficulties, the untiring industry, and the never-failing zeal, which realised such splendid results with such inadequate means.

I purposely kept out of sight all these interesting circumstances in the personal history of M. Goldschmidt, till I had led you dispassionately to consider the real value and merit of his discoveries independently of them, and his absolute superiority over his formidable rivals in the race of discovery;

because I consider it as a rule to be adhered to with the utmost tenacity in the bestowal of your Medal — a rule from which, indeed, your Council has never deviated — that the merit and the importance of the astronomical work which we propose to crown with our award must be considered apart from all personal considerations. Indeed I may say with perfect truth, that, to the best of my knowledge, no member of the Council, including myself, was aware of these circumstances; we knew solely that by profession M. Goldschmidt was an artist, but of his peculiar struggles and difficulties in achieving so great astronomical success we were all profoundly ignorant. But surely, Gentlemen, after that we have performed with the utmost rigour and impartiality our duty as astronomers, we may now at least indulge our natural feelings as men, and show before Europe, and especially before France, how we honour the character of him who, both in his scientific and his private capacity, has added to her fame, and who deserves from her such recognition as she so well knows how to give to her illustrious citizens.

It is now time that I turn from the consideration of the discoverers of these new members of our solar system to the results of their discoveries; and, in the first place, I wish I could tell you that through their means we had arrived at some definite theoretical conclusions regarding their origin and their mutual connexion with each other: but such is far from being the case. Isolated from all the greater planetary bodies, they form a ring of planets evidently belonging to a distinct system, and, it may be, having their origin in some great catastrophe countless ages ago. The idea of Olbers, that they were the shattered fragments of some large planet which once glittered in the sky like *Mars* or *Jupiter*, was poetically grand; and the hypothesis, in connexion with Bode's empirical law, was so plausible that even now many cling to it, and try to force facts into accordance with it. But the greater the number of discoveries, the less appearance of truth is there in the hypothesis. In a recent number of the *Nachrichten** is a notice of a paper by Mr. Newcomb, an American astronomer (published originally in the American *Philosophical Transactions*), in which he has arranged and discussed twenty-five of the orbits with reference to the hypothesis of a shattered planet, and he finds nothing whatever to justify this supposition. On this head let us be contented that Bode's law has done its work well: it set astronomers on the true trace for the discovery of the members of this singular system, and it helped to discover *Neptune*. Whether there be a correct law of planetary distances, of which this is a first approximation, or whether the planets have been placed arbitrarily at distances subject only to the ultimate laws of the Almighty Architect,

* No. 1288.

whose designs are unfathomable by us, remains still to be proved. Let it suffice, that in every new discovery we see an additional proof of the wonderfully simple and comprehensive law of gravitation; and that the filmy, vaporous masses of the comets, and these minute atoms, revolve in their appointed courses as unerringly as the ponderous masses of the larger planets.

There is one more consideration which I must lay before you, and it bears the same relation to the subject-matter of this address that the charitable appeal at the end of a sermon does to the theological arguments which may have preceded. I have to ask your assistance and advice with regard to these small members of the solar family. One has already, for want of needful care, gone astray, and, it is to be feared, will not be brought back to the path of rectitude in her orbit: *Daphne* is lost, and, as the numbers increase and the difficulty of providing for the observations and for the computation of the orbits increase in the same proportion, we must fear that other losses will follow, and the results of some of these interesting discoveries be neutralised. This difficulty is not felt now for the first time; and indeed, some few years ago, when the number of planets was comparatively small, an arrangement was made by the directors of several European and American Observatories to divide among them the labour of observing, each Observatory making itself responsible for a definite number of the planets, according to its observing force and instrumental equipment. I am not quite sure that this organisation is understood to exist at the present time: some members of it, at least, have ceased to take part in the operations, and the immense increase of the number of objects to be observed of itself makes it necessary that it should be reconstituted.

But the deficiency of observers does not form the chief difficulty of the case. By judicious arrangements, an association similar to that which I have mentioned, but established on a more permanent plan, and with officers charged with the duty of attempting to keep it in a condition sufficiently vigorous to meet all exigencies arising from the progress of discovery, could be formed without much difficulty; and I have no fear but that the increase of instrumental means and of observing force will, on the whole, keep pace with the progress of discovery. Several large telescopes are mounted equatoreally, both in Europe and America, which do but little work, and they could not be better employed than in taking a share in the operations of the proposed association. The deficiency of observing power is, therefore, not an insuperable difficulty: the difficulty is rather to provide systematically for the calculation of the orbits, and the computation and distribution of ephemerides for the use of the observers, as soon as possible after the discovery of a new planet.

It is well known that the Astronomer Royal undertakes

the meridian observations of all those planets which are visible at Greenwich; and this is a most valuable contribution on his part, and a most liberal interpretation of his duties in advancing speculative astronomy. But the difficulty of finding the requisite ephemerides of the daily motions of the planets so embarrassed the observers at Greenwich as at one time to to render useless at least half of the observing labour that had been expended. This induced him, as you may remember, to issue a circular addressed to the directors of the chief European Observatories, begging their assistance either in sending recent observations of newly-discovered planets or ephemerides of their motions. This circular was partially successful, and since the time it was issued much less labour is thrown away by the observers.

Still, something more is requisite to meet the present requirements; and all that I can suggest at present is, that the planetary association, when formed, should take the same charge of the computation of orbits and ephemerides as of the observation of the planets. Some Observatories which are not sufficiently well equipped to provide for observations might undertake the discussion of the early observations made by others, while the association might issue specimens of blank forms for the computations, which would make it practicable to put large masses of the work into the hands of comparatively inexperienced computers.

This, however, is not the time to enter into details respecting the plan which I have sketched; and, indeed, a very great deal of thoughtful consideration and discussion must take place before any plan can be devised sufficiently prudent to secure for the present the co-operation which is needed, and to make the proposed association available as a permanent institution.

In the discharge of the duty which has devolved upon me, I have thought it necessary to lay before you the necessity of some speedy mode of vigorous action, being certain that the currency given throughout the world to our Proceedings will at least make it probable that the matter may be taken up by some persons more competent to deal with the difficulty than I can pretend to be.

But, Gentlemen, such is the rate of progress of astronomical discoveries, and so prolific is each individual discovery as containing the germs of many others, or, what is the same thing, so inextricably mingled are the various branches of astronomical research, that our responsibilities do not end with the consideration of any one branch, such as that of planetary discoveries, which we have been considering. The same general survey, or mapping of the Northern heavens, which gave rise to these discoveries, has also advanced, and indeed almost created, another important branch of research, namely, that of variable stars. The number of known variables is now so

rapidly increasing, that provision for the systematic observation of them, and for the discussion of the results, will soon be as necessary as in the case of the small planets. Then, again, the Sun himself presents a rapidly increasing source of interesting matter for research and speculation. The same may be said of the Moon and the great planets, both as regards the analytical investigations relating to the perturbations of their orbits and to their physical peculiarities.

Thus, in whatever direction we turn our eyes, the same remarkable activity and marks of progress are presented to us. Powerful telescopes are continually directed to the heavens in every quarter of the globe, handled by men eager for discovery and intellectually competent to turn to the best account that which they may have discovered or seen. And as, on the earth, each small and apparently rude element teems with organised life, and gives ample employment to the microscope, so do the regions of infinite space, laid open to us by the telescope, in the heavens, teem with unexhausted wonders, which only require the intelligent mind and the keen eye of the astronomer to discover. The works of creation are as boundless at one extremity as at the other. Planets countless in numbers, but which no man has ever seen, probably still roll on in their silent orbits; stars, the centres of other systems as grand and as boundless as all that we behold on a winter night, offer mysterious peculiarities, only waiting for the record of future astronomers; phenomena still more curious than any yet revealed to us are still waiting their scrutiny and development.

Astronomy, after all, is a young science in all the aspects under which we are regarding it; and even at the beginning of the present century, after all the wonderful discoveries of the elder Herschel, not one of the subjects which I have touched on in this address would have found a place. There is no fear for the future, and we may, in anticipation, envy to our descendants the accumulation of facts and the comprehensive grasp which they will have of the science of the visible universe compared with ourselves. It is sufficient for us to know, as astronomers, that there is work — good and well-repaying work — remaining for us to do, and, as Christians and as men, to recognise the scantiness of our knowledge compared with the wonders of creation; and to exclaim with all humility, when we look up intelligently into the starry heavens, "Lord, how manifold are Thy works; in wisdom hast Thou made them all."

(*The President, then delivering the Medal to Admiral Manners, addressed him in the following terms*):—

Admiral Manners, — I request that you will have the goodness to transmit to M. Goldschmidt this medal, and to

accompany it with the best wishes of the Members of this Society for his future happiness and prosperity. Tell him how we sympathise with him in his early struggles, and how we admire the energy and devotion which enabled him to accomplish so much with means so utterly disproportionate; and assure him, finally, of the interest with which we shall watch his future career, and of our hope that he may ultimately be enabled to devote exclusively to Astronomy those talents which, under such disadvantageous circumstances, have produced such important results.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

John Lee, Esq. LL.D. F.R.S.

Vice-Presidents:

G. B. Airy, Esq. M.A. F.R.S. Astronomer Royal.
Rev. Robert Main, M.A. F.R.S.
Augustus De Morgan, Esq.
Rev. C. Pritchard, M.A. F.R.S.

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

Secretaries:

Richard C. Carrington, Esq. F.R.S.
Warren De La Rue, Esq. F.R.S.

Foreign Secretary:

Admiral R. H. Manners.

Council:

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Arthur Cayley, Esq. M.A. F.R.S.
Richard Farley, Esq.
Rev. George Fisher, M.A. F.R.S.
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W. S. Jacob, Esq.
Admiral W. H. Smyth, K.S.F. D.C.L. F.R.S.
Charles B. Vignoles, Esq. F.R.S.
Charles V. Walker, Esq. F.R.S.
Rev. Thos. Wm. Webb, M.A.

Discovery of a New Minor Planet.

A letter has been received from M. De Gasparis, dated Naples, 11th February, 1861, announcing his discovery of a new Planet, of the brilliancy of a star of the 10th magnitude. The position is

	Naples M.T.	App. R.A.	App. Decl.
1861, Feb. 10,	$14^h\ 33^m\ 18^s$,	$11^h\ 11^m\ 42^s.5$,	$+5^\circ\ 18'\ 49''$.

The comparison was made with 120 Weisse, hora xi., the adopted mean position of this star for January 1861 being

$$\text{R.A. } 11^h\ 8^m\ 28^s.93, \qquad \text{Decl. } +5^\circ\ 14'\ 24''.4.$$

The motion of the Planet in Declination is very small; that in R.A. is about -42^s daily.

ERRATUM.

Vol. xxi. p. 8, *for* June, *read* July in every place where it occurs.

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PART III.

PRINCIPLES OF FORMING THE MOST ADVANTAGEOUS COMBINATION OF FALLIBLE MEASURES.

PART IV.

ON MIXED ERRORS OF DIFFERENT CLASSES, AND CONSTANT ERRORS.

MACMILLAN AND CO.

Cambridge:

AND 23, HENRIETTA STREET, COVENT GARDEN,

London.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXI. *March* 8, 1861. No. 5.

Dr. Lee, President, in the Chair.

Rev. F. Howlett, Hurst Green;
Edmund Wheeler, Esq., 11 William Street, Upper Holloway;
Capt. H. C. Johnstone, 5th Bengal European Regiment;
Rev. M. A. Smelt, Heath Lodge, Petersfield; and
Andrew Yeates, Esq., 12 Brighton Place, New Kent Road,

were balloted for and duly elected Fellows of the Society.

Note on Prof. Wolf's latest Results on Solar Spots. By Joseph Baxendell, Esq.

In the "Abstract of his latest Results" (*Monthly Notice* for January 1861), Prof. Wolf announces the law that "greater activity on the Sun goes with shorter periods, and less with long periods;" but with reference to this law, it may be remarked, that although the numbers given by Prof. Wolf indicate a higher range of activity in short than in long periods, they also show that the total amount of action from one minimum to another is not materially influenced by the length of the period. Thus five periods, averaging 9·98 years each, give the mean value of the total amount of action = 449·2; whilst four periods, averaging 12·65 years each, give the mean value = 438·0. The near agreement of these two numbers for periods differing so considerably in length shows that the total amount of action cannot be regarded as being dependent to any great extent upon the length of the period; and it appears, therefore, that the higher range of activity in

short periods is, in fact, due to this near approach to equality in the amount of total action in periods of different lengths. There is, however, a remarkable relation indicated by Prof. Wolf's results which, though not noticed by him, is, perhaps, hardly less important and instructive than the law which he has announced.

If we denote by R the ratio of the intervals from minimum to maximum, and from maximum to minimum, we find that

Five periods, having a mean value of 12·36 years, give	$R = \frac{5 \cdot 12}{7 \cdot 24} = 0 \cdot 707$
Five periods, mean value 9·98 years	$R = \frac{4 \cdot 54}{5 \cdot 44} = 0 \cdot 834$
Five periods, having a mean maximum activity of 96·12, give	$R = \frac{3 \cdot 78}{7 \cdot 10} = 0 \cdot 532$
Five periods, having a mean maximum activity of 62·44, give	$R = \frac{5 \cdot 88}{5 \cdot 58} = 1 \cdot 053$
Five periods, having a mean total amount of action = 544·38, give	$R = \frac{3 \cdot 78}{7 \cdot 10} = 0 \cdot 532$
Four periods, having a mean total amount of action = 319·12, give	$R = \frac{5 \cdot 97}{5 \cdot 55} = 1 \cdot 075$
The mean value of R from all the periods in Prof. Wolf's list is	$R = \frac{4 \cdot 83}{6 \cdot 34} = 0 \cdot 761$

It appears, therefore, that the value of R is least in long periods and periods of great activity, and greatest in short periods and periods of diminished activity. Variations in the amount or in the maximum intensity of action, have, however, greater influence than changes in the length of the period.

As most of the variable stars have very unequal rates of increase and decrease of brightness, and as the ratio of these rates is also found to be affected by changes in the length of the period and in the range of variation of brightness, Prof. Wolf's results for the Sun give additional importance to the view taken by some astronomers, that the solar spots and the phenomena of the variable stars are produced by similar agencies.

Manchester, Feb. 20, 1861.

On the Persistency during three days of two light Patches on a Solar Spot. By W. R. Birt, Esq.

On the 9th of July, 1860, between 3^h 30^m and 5^h G.M.T., I observed and figured an interesting solar spot on the southern

hemisphere of the sun, fig. 1. It consisted of a somewhat large nucleus surrounded by a penumbra, the northern part of which was separated from the main body by a bridge of light, and several small spots were seen as outlines, mostly in the direction of the longest diameter of the penumbra.

Fig. 1.

1860, July 9, 4^h 45^m.

The most interesting features characterising this spot were:—

1°. A dark tongue or spur of a curved form, the convexity being towards the nucleus, it was *only just* attached to the main body of the nucleus and *apparently* a portion of it.

2°. Bordering the eastern part of the nucleus, and partially separating the dark tongue or spur, a bright patch of light was seen, A, fig. 1.

3°. Another bright patch of light was noticed north of the spur, and projecting from the curved portion at a considerable angle, B, fig. 1.

On the 11th of July, between 4^h 30^m and 5^h G.M.T., I again figured the same spot, fig. 2; every portion had undergone a very considerable change, the outlines of both nucleus and penumbra having altered materially, the surface of the

Fig. 2.

1860, July 11, 4^h 45^m.

Fig. 3.

1860, July 12, 4^h 15.

penumbra appeared to be exceedingly mottled from numerous small light patches scattered over it, the spur seen on the 9th was recognised as well as the two light patches, A and B, fig. 2, the relative positions being unchanged both as regarded direction and locality in the spot.

About 24 hours later, viz. on July 12th, from 3^h 30^m to 5^h G.M.T., all the features of the spot, except the spur and the two light patches, had undergone very remarkable changes, the nucleus was much elongated, and the spur entirely separated, the penumbra exhibited appearances of having been subject to considerable agitation (see fig. 3) at the western extremity of the nucleus, a lighter portion surrounding it crossed by a narrow and dark bridge appeared to have drawn the material of the penumbra westwardly, while the two light patches seen on

the 9th and 11th maintained their positions (A and B, fig. 3), the outline of the penumbra was very irregular, and towards the eastern extremity was broken into several angles, a portion of the penumbra itself being separated from the main body of the spot by the two persistent light patches.

It is not a little remarkable, and a matter that deserves close attention, that while every other portion of the spot underwent considerable change, the two patches of light with the spur maintained at least the same relative positions with regard to each other; observed at first in the eastern portion of the spot, while evidence was afforded of increasingly energetic action by which the nucleus was elongated *westwards* and the penumbra driven in the same direction, the patches of light preserved nearly the same form and inclination to each other accompanied by the spur (a part of the nucleus), which although it did not alter its relative position with regard to them, yet underwent modifications in form which did not appear to affect them. It would seem that from the neighbourhood of the two light patches a force of sufficient energy to extend the spot westwardly was in active operation, while eastwardly the action was confined to modifying the penumbra and altering the form of the spur.

On the Apparent Rotation of a Solar Spot.
By W. R. Birt, Esq.

On the 29th of October, 1860, about 23^h G.M.T., I carefully observed and figured a solar spot, see sketch, fig. 1. The

Fig. 1.

1860, Oct. 29, 23^h 0^m.

Fig. 2.

1860, Oct. 31, 22^h 30^m

next opportunity I had of viewing this spot was on October 31, *about* 22^h 15^m, when I again made a sketch of it, see fig. 2.

During the 47 hours and a quarter that elapsed between the two a very considerable change had taken place, and some indications of rotation were afforded.

The spot on the 29th presented a feature by no means rare, viz. the presence of a principal, and also of a secondary nucleus, the breadth by estimation* of the southern or broadest part of the principal nucleus was about 15″, the longest diameter being directed towards the north-west, the nucleus ending in a fine point, the eastern side of the nucleus being convex while the western was concave. The secondary nucleus was westward of the principal, irregular in its form, the northern part being curved, the parallelism of the two nuclei was distinctly apparent.

The outline of the penumbra presented the ordinary irregular character, the curved portion of the secondary nucleus and the outline of the penumbra were in contact.

On the 31st, a remarkable change was observed in the two nuclei, the southern portion of the principal nucleus was still the broadest, and occupied much the same position, but the two sides were altered exceedingly, the western side was smoothly convex; and the eastern smoothly concave with a marked protuberance. As on the former occasion the nucleus terminated towards the north in a fine point.

The secondary nucleus had changed its form and position considerably, it appeared as if all its material had progressed so as to have met with such a resistance as to have produced a smooth curvilinear outline, broadest at the front and gradually tapering to a point, the figure strongly suggests the idea of semi-fluidity, the same contact of the penumbral outline with the front of the secondary nucleus observed on the 29th was also seen on the 31st, but in such a position as strongly to suggest a rotation of the entire spot, and also that the secondary nucleus in its motion northward had turned the point of the principal nucleus, the centre of motion being in the neighbourhood of the broadest portion of the principal nucleus.

The longest diameter of the spot was much in the same direction as on the 29th, it however appeared more marked on the 31st, as the spot was foreshortened by its approach to the limb, the parallelism of the two nuclei being very apparent, but not in the direction of the longest diameter of the spot.

On November $1^{d}\ 21^{h}\ 15^{m}$, G.M.T., I obtained another sketch, fig. 3, of this spot. As it approached the limb, it not only apparently, but I apprehend really, increased in magnitude, the evidence of rotation being still very marked around the southern part of the principal nucleus. It would appear that this part of the nucleus had become broader, the point observed on the two former occasions was blunted and a

* This estimation was obtained by means of an etched glass micrometer, constructed for me by L. Casella, Esq., the value of each division being a little more than 1′.

somewhat thick dark line extended from the principal towards the secondary nucleus, which had evidently increased considerably in size since Oct. 29th. As on the two former occasions the parallelism of the two nuclei was maintained, the further indication of rotation consisting in the advance of the secondary nucleus in an eastward direction, the whole body of the spot being apparently carried round with it.

On the 31st of October a streak of light divided the penumbra in the neighbourhood of the south-western part of the principal nucleus, this had so considerably increased by November 1^d 21^h 15^m as to leave a portion of the principal nucleus without any penumbral appendage, the contact of the secondary nucleus with the edge of the penumbra being still maintained.

Nov. 2^d 21^h 45^m. Nearly the same features were presented accompanied with an evident arrestation of the rotatory movement, and a very slight divergence from parallelism in the two nuclei. Sketch, fig. 4, exhibits the appearance of the spot at

Fig. 3.

1860, Nov. 1, 21^h 30^m.

Fig. 4.

1860, Nov. 2, 21^h 30^m.

this epoch, and shows the great change that had supervened in the positions and appearances of the nuclei during the 95 hours the spot had been under observation; this sketch is very instructive, and indicates, I apprehend unmistakeably, that the apparent rotation is due to the motion of the secondary nucleus, sketches 2 and 3, exhibiting successive steps in the divergence of the nuclei, a fact spoken of repeatedly by Mr. Carrington. Shortly after the completion of sketch 4 the long thin line nearly connecting the principal with the secondary nucleus was observed breaking up into two or three small

spots; and during the progress of the sketch the penumbra underwent change, several lucid portions within its boundary were noticed near the nuclei, and generally much more energetic action was manifested upon the cessation of the apparent rotatory motion than while it was in progress; there also appeared to be indications of internal curvilinear motion.

An Auxiliary Table for the Easy Calculation of Log. sin. and Log. tan. of Small Arcs. By S. M. Drach, Esq.

The table which I herewith offer to the Royal Astronomical Society has been found by me to be very useful, especially at the beginning of the quadrant, obviating the necessity of interpolations in the ordinary "small arc log. sin., &c." table, and could be appended in detached portions to seven fig. logs. of numbers. Thus to find, by means of it, log. sin. and log. tan. of 7′ 34″·82.

$$7' \, 34''\cdot82 = 454''\cdot82$$

Log 454″·82	= 2·6578396		2·6578396
Tab. 8′ sin.	= 4·6855745	Tab. 8′ tan.	4·6855756
log. sin 7′ 34″·82	7·3434141	log. tan.	7·3434152

But for this purpose the logs. of numbers must be extended to 10800.

A great advantage would result from prefixing a column to the No. in the logs. of numbers indicating the deg. and min. of the No., considered as denoting a number of seconds.*

With such a table the proportional logarithms of nautical tables might be dispensed with, the constant for 3^h or 3° being 10800 or 4·0334238. Thus, suppose the Greenwich three hourly distances of the Moon from a star, according to the *Nautical Almanac*, be 1° 12′ 21″, and the observer finds his corrected distance to be 1° 4′ 12″, the interval for Greenwich time would be thus computed:—

C. log 10800 (3^h)	= 4·0334238
Subtract log 4341 (1° 12′ 21″)	3·6375898
	0·3958340
Add log 3852 (1° 4′ 12″)	3·5846863
$2^h \, 39^m \, 21^s\cdot4$ = 9561″·4 = log.	3·9805203

* This is done at the foot of the page in Bremiker's Tables, Berlin, 1852.—Ed.

The Greenwich interval is then $2^h\ 39^m\ 21^s{\cdot}4$, and the number 3958340 in the *Nautical Almanac* column in lieu of the "P. L. of Diff." (no log. index required), would give nearer results, with the advantage of not changing the formula sine, cosine, &c. to the P. L. cosec., sec., &c.

Auxiliary Table for Small Arcs.

To find the log. sin. or the log. tan. add to the log. number of seconds the number in the column sin. or tan. of this Table. The number to be added commences 4·685, the columns of the Table giving the remaining decimals.

Arc. ° ′	No. of Sec^{ds}.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
0 1	60	5748	...	5748	...
2	120	5748	...	5749	...
3	180	5748	...	5750	...
4	240	5748	...	5751	...
5	300	5747	...	5752	...
6	360	5746	...	5753	...
7	420	5746	...	5755	...
8	480	5745	...	5757	...
9	540	5743	...	5758	...
10	600	5742	...	5760	...
11	660	5741	...	5763	...
12	720	5740	...	5766	...
13	780	5738	...	5769	...
14	840	5737	...	5773	...
15	900	5735	...	5776	...
16	960	5733	..	5780	...
17	1020	5731	...	5784	...
18	1080	5728	...	5788	...
19	1140	5726	...	5792	...
20	1200	5725	...	5898	...
21	1260	5722	...	5803	...
22	1320	5719	...	5808	..
23	1380	5716	...	5813	...
24	1440	5713	...	5819	...
25	1500	5710	...	5825	...
26	1560	5707	...	5831	...
27	1620	5704	...	5838	...
28	1680	5700	...	5845	...
29	1740	5698	...	5852	...
30	1800	5694	...	5859	...
31	1860	5690	...	5867	...
32	1920	5686	...	5874	...
0 33	1980	5682	...	5882	...

Arc. ° ′	No. of Sec^ds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
0 34	2040	5678	...	5890	...
35	2100	5674	...	5899	...
36	2160	5669	...	5907	...
37	2220	5665	...	5916	...
38	2280	5661	...	5926	...
39	2340	5655	...	5935	...
40	2400	5651	...	5945	...
41	2460	5646	...	5955	...
42	2520	5641	...	5965	...
43	2580	5635	...	5975	...
44	2640	5630	...	5986	...
45	2700	5624	...	5996	...
46	2760	5619	...	6008	...
47	2820	5613	...	6019	...
48	2880	5607	...	6031	..
49	2940	5602	...	6043	...
50	3000	5595	...	6056	...
51	3060	5590	...	6068	...
52	3120	5585	...	6080	...
53	3180	5577	...	6093	...
54	3240	5570	...	6106	...
55	3300	5564	...	6120	...
56	3360	5556	...	6133	...
57	3420	5550	...	6147	...
58	3480	5543	...	6161	...
0 59	3540	5535	...	6175	...
1 0	3600	5528	...	6190	...
1	3660	5521	...	6204	...
2	3720	5514	...	6220	...
3	3780	5506	...	6235	...
4	3840	5498	...	6251	...
5	3900	5490	...	6266	...
6	3960	5482	...	6282	...
7	4020	5473	...	6298	...
8	4080	5465	...	6315	...
9	4140	5457	...	6332	...
10	4200	5448	...	6349	...
11	4260	5440	...	6366	...
12	4320	5432	...	6384	...
13	4380	5422	...	6402	...
14	4440	5413	...	6419	...
15	4500	5404	...	6438	...
1 16	4560	5395	10	6457	18

Arc. ° ′	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
1 17	4620	5385	9	6475	19
18	4680	5376	9	6494	20
19	4740	5367	10	6514	19
20	4800	5357	10	6533	19
21	4860	5347	10	6552	20
22	4920	5337	10	6572	21
23	4980	5327	10	6593	21
24	5040	5317	11	6614	20
25	5100	5306	10	6634	21
26	5160	5296	10	6655	21
27	5220	5286	11	6676	22
28	5280	5275	12	6698	23
29	5340	5263	11	6719	22
30	5400	5252	10	6741	23
31	5460	5242	12	6764	21
32	5520	5230	11	6785	23
33	5580	5219	11	6808	23
34	5690	5208	13	6331	23
35	5700	5195	11	6854	24
36	5760	5184	12	6878	23
37	5820	5172	11	6901	25
38	5880	5161	12	6926	24
39	5940	5149	13	6950	23
40	6000	5136	12	6973	26
41	6060	5124	12	6999	25
42	6120	5112	13	7024	24
43	6180	5099	13	7048	26
44	6240	5086	12	7074	26
45	6300	5074	13	7100	25
46	6360	5061	13	7125	27
47	6420	5048	14	7152	26
48	6480	5034	13	7178	27
49	6540	5021	13	7205	27
50	6600	5008	14	7232	27
51	6660	4994	14	7259	26
52	6720	4980	13	7285	28
53	6780	4967	14	7313	28
54	6840	4953	14	7341	28
1 55	6900	4939	14	7369	29

Arc. ° ′	No. of Sec^ds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
1 56	6960	4925	15	7398	28
57	7020	4910	15	7426	28
58	7080	4895	14	7454	30
1 59	7140	4881	14	7484	29
2 0	7200	4867	15	7513	30
1	7260	4852	15	7543	29
2	7320	4837	15	7572	30
3	7380	4822	15	7602	31
4	7440	4807	16	7633	30
5	7500	4791	15	7663	31
6	7560	4776	16	7694	31
7	7620	4760	15	7725	31
8	7680	4745	16	7756	31
9	7740	4729	15	7787	33
10	7800	4714	16	7820	32
11	7860	4698	17	7852	32
12	7920	4681	16	7884	32
13	7980	4665	16	7916	33
14	8040	4649	16	7949	33
15	8100	4633	18	7982	33
16	8160	4615	16	8015	34
17	8220	4599	16	8049	34
18	8280	4583	18	8083	33
19	8340	4565	17	8116	34
20	8400	4548	17	8150	35
21	8460	4531	17	8185	35
22	8520	4514	18	8220	34
23	8580	4496	17	8254	36
24	8640	4479	19	8290	35
25	8700	4460	17	8325	36
26	8760	4443	18	8361	36
27	8820	4425	18	8397	36
28	8880	4407	18	8433	37
29	8940	4389	18	8470	36
30	9000	4371	19	8506	37
31	9060	4352	18	8543	37
32	9120	4334	19	8580	37
33	9180	4315	19	8617	38
2 34	9240	4296	18	8655	38

Arc. ° ′	No. of Sec^{ds}.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
2 35	9300	4278		8693	
36	9360	4259	19	8732	39
37	9420	4239	20	8770	38
38	9480	4220	19	8808	38
39	9540	4200	20	8847	39
40	9600	4131	19	8886	39
41	9660	4161	20	8926	40
42	9720	4141	20	8965	39
43	9780	4121	20	9004	39
44	9840	4101	20	9045	41
45	9900	4081	20	9085	40
46	9960	4061	20	9126	41
47	10020	4041	20	9167	41
48	10080	4020	21	9208	41
49	10140	3999	21	9249	41
50	10200	3978	21	9290	41
51	10260	3957	21	9332	42
52	10320	3937	20	9375	43
53	10380	3915	22	9416	41
54	10440	3894	21	9460	44
55	10500	3873	21	9502	42
56	10560	3851	22	9546	43
57	10620	3830	21	9589	43
58	10680	3807	23	9632	43
2 59	10740	3786	21	9676	44
3 0	10800	3764	22	9720	44

Watford, Herts, March 4, 1861.

From a Letter from Professor Hansen to the Astronomer Royal, dated Gotha, 1861, *Feb.* 2.

(*Translated from the German.*)

"You express in your honoured letter the wish that I would soon publish the calculation of my Lunar Perturbations, and I can assure you that I myself fully take part in that wish. I am even occupied, as far as my other labours permit, with the performance of this: a work of tolerable size is already finished, and I hope soon to be in a condition to draw up the manuscript for press for the first treatise. As far as I have yet advanced in the new calculations, I have found no differ-

ence from the coefficients used in the Lunar Tables, which amounts to $0''\cdot 1$; the new coefficients differ, at the most, from those of the Lunar Tables by a few hundredth parts of a second. My plan in this new investigation of the Lunar Perturbations stands firm, and cannot be altered.

"You wish further to know what I understand by the expression in my letter of 1854, Nov. 3, 'In my Lunar Tables I have provisionally used coefficients, which are not free from some empiricism,' and I will willingly communicate this to you. In the first place, I mean thereby the part of the motion of the line of nodes and of the line of apsides which is proportional to the time itself; and in the next place, the coefficient of the argument 8 V — 13 E; nothing further, unless also the determination of the coefficient of the parallactic equation by observations be called empiricism. In order to be able to calculate those coefficients by theory alone, with such accuracy that they could be employed in the tables without anything further, one would be obliged to calculate the coefficients of the periodical perturbations with far greater exactness than is otherwise demanded; and this I considered to be superfluous, as it would have engrossed very much time. For the rest, I have found the coefficient of 8 V — 13 E, by my last theoretical determination of it, by no means insensible, like Delaunay. Without the introduction of this coefficient, the observations show deviations at different epochs; but with the introduction of this, these deviations disappeared even to the last trace. I considered, therefore, its introduction as established, and reserve to myself a new theoretical determination of it, but cannot take this in hand until I shall have proceeded further in the new calculation of the remaining coefficients. I have, besides, some other inequalities of long period, which are caused by the planets; but as the coefficients of these inequalities are small, I have neglected them in the tables, in order to avoid too great extension.

"It is probably the recent publication of Delaunay which has led you, most highly-honoured colleague, to the inquiry which I have plainly answered above; and I see myself compelled, in relation thereto, to add that, in the comparison with the observations, I have taken in no old eclipse or other ancient observation. I have never gone beyond Bradley's observations, and nevertheless my tables represent the ancient observations with satisfactory agreement.

"I have already shown that the ancient eclipses cannot be satisfied by the secular variation of Adams and Delaunay (*Comptes Rendus*, tome l. No. 10). I have now made trial of it, omitting the inequality dependent upon 8 V — 13 E, but find the effect of this very trifling, and almost the same enormous differences. I would gladly have said nothing of this until my new calculation of the secular variation was finished; but with the inducement which you have given me, I cannot

refrain from bringing forward what I have found about a year ago in relation to this. The method which Messrs. Adams and Delaunay have pursued in the calculation of the secular variation of the moon's mean longitude requires, in the co-ordinates or the elliptic elements of the moon, the introduction of terms of the following form:—

$$a t \begin{matrix}\sin\\ \cos\end{matrix}\left\{ig + i'g' + \mathrm{K}\right\} + \frac{b}{n}\begin{matrix}\cos\\ \sin\end{matrix}\left\{ig + i'g' + \mathrm{K}\right\} \ldots\ldots \quad (\mathrm{A})$$

where a and b are numerical coefficients, i and i' whole numbers, g and g' the mean anomalies of the Moon and of the Sun, K a function of the perihelion and of the nodes, and n the secular mean motion of the Moon. Against this nothing can be said; and Plana and Pontécoulant, who have attacked this principle, are in this respect in error. Methods, indeed, can be given in which the second class of the above-mentioned terms do not come into consideration; but if this matter be treated as Adams and Delaunay have done, these terms must be introduced. But—whence do these terms arise? They arise out of the following terms of the Sun's co-ordinates:—

$$a' t \left.\begin{matrix}\sin\\ \cos\end{matrix}\right\} i'g' + \frac{b'}{n}\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\} i'g' \ldots\ldots\ldots\ldots\ldots\ldots \quad (\mathrm{B})$$

and the method which requires the complete taking into account of the terms (A) requires, of course, also the complete taking into account of the terms (B), and these are not small. The greatest of the coefficients denoted by b' exceeds $90''$. Further, the part of the perturbation-function of the Moon depending upon the planets contains terms which may also contribute to the secular variation of the Moon's mean longitude; these are, however, smaller than those above.

"All the memoirs of Messrs. Adams and Delaunay on this matter which have come into my hands I have carefully looked through, but I have not been able to remark that regard had been taken of the above coefficients denoted by b', or of those depending upon the planets. Until I am convinced of the contrary, therefore, I must assume that these terms have not been taken into account; and I have in this, again, a ground for the suspicion that Delaunay may also have overlooked terms in the latest calculation of the coefficient of 8 V − 13 E.

"I can, besides, affirm that even in Adams' first memoir (received and read June 16, 1853) combinations have been overlooked* which, indeed, for the coefficient there calculated, accidentally destroy each other, but whose continued omission must necessarily make the terms of the higher orders incorrect. We find, in the memoir named, in the longitude,

* In the original thus, "die zwar für den dort berechneten Coefficienten sich zufällig aufheben, aber deren fortgesetzte Uebergehung nothwendig die Glieder der höheren Ordnungen unrichtig machen muss."—Ed.

$$+\frac{295}{24}m^2\frac{e'\,d\,e'}{n\,d\,t}\cos(2\,\nu-2\,m\,\nu)-\frac{413}{48}m^2\frac{d\,e'}{n\,d\,t}\cos(2\,\nu-2\,m\,\nu-c'\,m\,\nu)*$$

$$+\frac{59}{48}m^2\frac{d\,e'}{n\,d\,t}\cos(2\,\nu-2\,m\,\nu+c'\,m\,\nu);*$$

while these coefficients are respectively =

$$+\frac{74}{3}m^2,\qquad -\frac{215}{48}m^2,\qquad +\frac{257}{48}m^2.$$

In the radius, we there find

$$+\frac{95}{12}m^2\frac{e'\,d\,e'}{n\,d\,t}\sin(2\,\nu-2\,m\,\nu)-\frac{133}{24}m^2\frac{d\,e'}{n\,d\,t}\sin(2\,\nu-2\,m\,\nu-c'\,m\,\nu)*$$

$$+\frac{19}{24}m^2\frac{d\,e'}{n\,d\,t}(\sin 2\,\nu-2\,m\,\nu+c'\,m\,\nu);*$$

while these coefficients are respectively

$$+\frac{203}{12}m^2,\qquad -\frac{61}{24}m^2,\qquad +\frac{91}{24}m^2.$$

"It appears that the combination of the term $3\frac{d\,e'}{n\,d\,t}\cos c'm\,\nu$ with the other entering terms has been overlooked.

"In conclusion, I must remark that I shall never be able to favour the development of the Lunar Perturbations in series according to the powers of m, unless it is proved,

"(1.) That these series converge;

"(2.) If this is the case, that the sum of the undeveloped terms of each one of these series can be assigned with sufficient approximation.

"That the first terms of a series decrease is no proof of the convergence of a series, for many diverging series can be brought forward in which this case occurs. It is also known that in slowly converging series the sum of the small terms not taken into account may often amount to something considerable."

Results of Observations of the Solar Eclipse of 1860, *July* 18, *made at the Royal Observatory, Greenwich, for determination of the Errors of the Tabular Elements of the Eclipse.* By G. B. Airy, Esq., Astronomer Royal.

Before leaving the Observatory for observation of the Totality of the Eclipse in Spain, I drew up a set of Instructions

* In Prof. Hansen's manuscript the coefficients of these terms are written $\frac{e'\,d\,e'}{n\,d\,t}$.—Ed.

for observation of the Eclipse at Greenwich, framed with the intention of giving means for ascertaining the errors of all the tabular elements of the Eclipse, namely, the difference of right ascension of centres of Sun and Moon, difference of north polar distance of centres of Sun and Moon, and semidiameters of Sun and Moon. The general scheme was as follows:—

1. From the beginning, at $1^h\ 38^m$, Greenwich mean solar time, to $1^h\ 55^m$, observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of Moon's R.A., increased by an excess of sum of semidiameters.

2. From $1^h\ 55^m$ to $2^h\ 15^m$, observations of the difference of R.A. of the cusps were to be made. These would show an effect principally of excess of Moon's N.P.D.

3. From $2^h\ 15^m$ to $2^h\ 45^m$, observations of the difference of R.A. of the Sun's 1 L. and Moon's 1 L. were to be made. These would show an effect of excess of Moon's R.A., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

4. From $2^h\ 45^m$ to $3^h\ 20^m$, observations of the difference of N.P.D. of Sun's N. L. and Moon's N. L. were to be made. These would show an effect of excess of Moon's N.P.D., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

5. From $3^h\ 20^m$ to $3^h\ 53^m$ (the end), observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of R.A. of Moon's centre, diminished by an excess of sum of semidiameters.

The observations No. 5 would form a valuable combination with No. 1, but they were not absolutely necessary. A very slight examination of the scheme will show that Nos. 1, 2, 3, 4, will give all the corrections of elements required.

The observations were made with the Great Equatoreal, under the general superintendence of Mr. Main, by Mr. Carpenter, assisted by Mr. Criswick and junior computers in the reading of microscopes, &c. The observations, Nos. 1, 2, 3, 4, were obtained in full number; the numbers of comparison-pairs being respectively 12, 27, 19, 18; but No. 5 was totally lost from clouds.

The observed measures were compared with the corresponding quantities computed by a laborious process from the places in the *Nautical Almanac*. To every numerical element of the *Nautical Almanac* was attached a symbolical correction, and the multiples of these symbolical corrections, affecting each of the quantities measured (whether depending on cusps or on limbs, and whether in R.A. or in N.P.D.), were carefully computed. Thus the comparison of each measured quantity with the corresponding computed quantity gave an equation containing multiples of all the corrections to elements and one numerical term.

Without entering further into the details (which will more

properly appear in the *Greenwich Observations*) the corrections were found as follows:—

Correction to excess of Moon's R.A. over Sun's R.A.	$-38''.63$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	$-\ 8.75$
Correction to Sun's Semidiameter	$-\ 1.45$
Correction to Moon's Semidiameter	$-\ 2.97$

To these I may add the following:—

Mr. Ellis found, by an imperfect meridian observation of the Sun,—

Correction to Sun's R.A. $+0^{s}.13$; to Sun's N.P.D. $-2''.49$

And, by good altazimuth observations of the Moon,—

Correction to Moon's R.A. $-2^{s}.40$; to Moon's N.P.D. $-4''.57$

Hence,

Correction to excess of Moon's R.A. over Sun's R.A.	$-37''.95$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	$-\ 2.08$

Of the two sets of results, those from the Equatoreal observations are undoubtedly by much the more accurate.

These corrections, it will be remembered, apply to the places in the *Nautical Almanac;* that is, to places computed by Burckhardt's Tables.

From the numbers given by Mr. Hind, in his circulated calculations of the eclipse, it appears that the places of the Moon given by Hansen's Tables, on July 18, 1^{h}, differ from those given by Burckhardt's Tables, by $-\ 2^{s}.33$ in R.A. and $-4''.0$ in N.P.D.; and the Moon's semidiameter from Hansen's Tables is less than that from Burckhardt's by $0''.6$. Also the places of the Sun given by Le Verrier's Tables differ from those given by Burckhardt's Tables, by $+\ 0^{s}.17$ in R.A. and $+\ 0''.8$ in N.P.D.; and the Sun's semidiameter from Le Verrier's Tables is less than that from Carlini's Tables by $1''.7$. Using these in combination with the numbers above, it appears that the corrections to the results from Hansen's and Le Verrier's Tables were

Correction to excess of Moon's R.A. over Sun's R.A.	$-1''.1$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	-4.0
Correction to Sun's Semidiameter	$+0.3$
Correction to Moon's Semidiameter	-2.4

Royal Observatory, Greenwich,
1861, *March* 6.

B

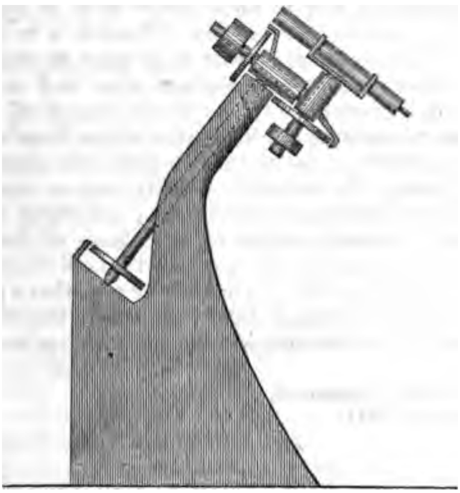
Suggestion of a new Astronomical Instrument, for which the name "Orbit-Sweeper" is proposed. By G. B. Airy, Esq., Astronomer Royal.

In reflecting on the possibility of picking up De Vico's comet, by aid of the sweeping ephemeris prepared by Mr. Hind, I could not but observe how ill adapted for this purpose are the instruments in ordinary use. It will be remarked that, in this and similar cases, it is not a general search in all directions about a given point that is required. For every day, places are computed which lie in a definite line drawn upon the celestial sphere; and, while it may be requisite to sweep many degrees along that line, it will be useless to direct the telescope many minutes above it or below it. The geometrical conception of the matter will at once explain this. The elements of the comet's orbit, considered as a curved line through space of three dimensions, are known with considerable accuracy; but the time of the comet's return to perihelion is not known with accuracy, and therefore the actual place of the comet upon that curved line is not known with accuracy; all that is accurately known being, that the comet will be somewhere on that line. And in fact, the definite line drawn upon the celestial sphere (of which I have spoken) is the perspective representation of a portion of the comet's orbit as viewed at a certain instant of time from the earth; and therefore the optical place of the comet must be somewhere upon that line traced on the celestial sphere, but we cannot say exactly where.

An unmounted telescope can scarcely be used to sweep along a definite track through the sky, which is defined by numerical elements of right ascension and north polar distance, but cannot easily be referred to distinguishable stars occurring in the breadth of every field of view. And the mounting which for all ordinary purposes is the most convenient, namely, that of the equatoreal, cannot be easily applied here. For sweeping in right ascension only, or (with the aid of clockwork movement, which every equatoreal ought to have) for sweeping in polar distance only, it is excellent; but for sweeping in an inclined direction, it is no better than an unmounted telescope.

I have arranged a form of mounting adapted to sweeping in all directions, a model of which (of about half-size dimensions) I ask leave to exhibit to the Society. The general form of the instrument is that of a German Equatoreal. The polar axis is similar to that of a German Equatoreal; but, in order to allow freedom of rotation to all parts, the fixed mass in which the polar axis turns must not be a pier widening downwards from the upper bearing of the polar axis, but must for some distance be a hollow tube or trunk. The cross-axis will be similar to that of a German Equatoreal; but instead of carrying the Telescope, it will carry a small trunk in which a second cross-axis turns.

This second cross-axis carries the Telescope. The polar axis should have a divided hour-circle, and clock-work movement (omitted in the model), the first cross-axis must have a graduated circle, and a clamp or steps by which it may be firmly fixed in a given position; the second cross-axis carrying the telescope must have a graduated circle, and must have two stops limiting its sweeping motion to any arbitrary extent. The second cross-axis must have a counterpoise for the telescope; the first cross-axis must have a counterpoise sufficient to balance both the telescope and the telescope's counterpoise. The annexed figure was drawn from the model.



It will be easily seen that, by giving a proper position in rotation to the first cross-axis, the inclination of the second cross-axis to an astronomical meridian may be made any whatever, and therefore the inclination of the circle in which the telescope will sweep may be made any whatever; and it may be made to coincide with the definite line drawn on the celestial sphere in which the comet is to be sought. And, by means of its stops, the extent of that line through which its sweep is to be made may be limited as we may think fit.

To such an instrument I would propose to attach the name "Orbit-Sweeper."

If I were to construct such an instrument expressly for the purpose of sweeping orbits, I would make it of wood. Such a construction would be more than sufficiently accurate for the purpose in question; its expense would be very small, it would be lighter than metal, for the same degree of stiffness; and its counterpoises, &c. would be light.

But it would be easy to adapt a common German Equatoreal to the same purpose, if the support of the polar axis widened out so little as to allow the telescope-counterpoise on the second cross-axis to rotate round it (for which purpose it might be worth while to substitute a trunk-support, as is described above). The possible inconveniences would be, that the counterpoises would be rather heavy, and that there might be a little instability from the use of three axial movements instead of two. The ordinary use of the Equatoreal would in no way be impeded.

There is one special application of such an instrument which deserves notice. It is known to lunar-observers and to lunar-photographers, and to none better than to some of the active members of this Society, how difficult it is to follow the Moon with an equatoreal. Now it is easy to compute the Moon's apparent motion in right ascension and north polar distance (both corrected for the continued change of parallax), and therefore to compute the inclination of the Moon's apparent orbit through the sky; and to this the Orbit-Sweeper might be at once adjusted. It would be equally easy to compute the Moon's apparent velocity in that orbit; and there must be a special clock movement, acting on the clamp of the circle of second cross-axis, with the proper speed; there would be little difficulty in arranging this. Thus I anticipate that a given spot on the Moon might be automatically kept for a long time under the cross wires of a telescope without discoverable motion.

Royal Observatory, Greenwich,
March 6th, 1861.

Mr. C. V. Walker received from the Astronomer Royal, and with his permission communicated to the Society, some letters and a paper on Controlling Clocks by Electricity.

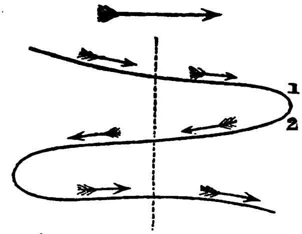
In a letter, dated 18th Feb. 1861, Mr. Airy writes: —

"I have been reading your interesting account of the time-signal operations, which will convey a great deal of information to the public.

"In regard to the interruption of the duration of action of the foreign current upon the pendulum, I think it will not succeed, for the following reason:—Let the curve which follows be understood to represent the pendulum-oscillations, the uniform course of time being downwards, and the direction of motion of the pendulum being shown by the arrows. Also, let the external arrow show the direction of the foreign force. The figures 1 and 2 merely show which part of the swing is, 1 towards the right and 2 towards the left.

"Now the rule for efficiency of external force in maintaining

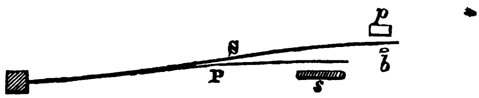
pendulum-motion is this:—If the direction of force agrees with the direction of motion, it maintains the vibration; if it is opposed, it diminishes the vibration. Thus, if the external



force act during any part of 1, it maintains the vibration; if during any part of 2, it diminishes it; if equally on both, it produces no effect.

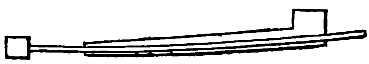
"Now any ordinary spring-contact that your pendulum can make will equally affect 1 and 2, and therefore will not serve. It will expose you as much to the chance of force opposing the vibration as of force assisting the vibration.

"Possibly you may do it in some such way as this:—



S, Spring.
P, Passing spring.
s, Pendulum stud.
b, Banking pin.
p, Piece carried by a spring for contact,

the arrangement of spring and passing-spring exactly as in my 10-inch clock; the form of the passing-spring, as you look from above, being



Then the pendulum-stud, in swinging to the right, will lift the passing-spring and the spring to contact, but will let it snap down before the end of vibration. In swinging to the left, it will press the passing-spring only down, and at last let it snap up.

"The spring-work must be very light."

And with a subsequent letter, dated the 20th Feb., was sent a paper containing the theory of the subject, as follows:—

Theory of the Regulation of a Clock by Galvanic Currents acting on the Pendulum. By G. B. Airy, Esq., Astronomer Royal.

I. Effect of force upon a pendulum.

The long curve is supposed to represent the swing of the pendulum; and the long arrows represent the direction of its swing. The short arrows represent the direction of a galvanic force, and the place of the pendulum when the galvanic force is acting.

At No. 1	the force	quickens the rate most,	does not alter the arc,
2	—	quickens the rate,	increases the arc,
3	—	does not alter the rate,	increases the arc most,
4	—	retards the rate,	increases the arc,
5	—	retards the rate most,	does not alter the arc,
6	—	retards the rate,	diminishes the arc,
7	—	does not alter the rate,	diminishes the arc most,
8	—	quickens the rate,	diminishes the arc,
1	—	quickens the rate most,	does not alter the arc.

If the galvanic force act the opposite way, the figure may be turned round the vertical line in its own plane, so as to reverse the figure in regard to right and left, and every remark is still correct.

II. In applying this to the regulation of a clock, it must be borne in mind,—

1st. As it is essential that the clock should continue to go (though erroneously) when the galvanism is accidentally interrupted, the galvanic force is always to be supposed subordinate to the maintaining power in the clock.

2d. The galvanic force must be large enough to do its duty of regulation, and, therefore, when applied at the most favourable place (No. 1 or 5, as the case may be), the galvanic force must be too large and must overdo the regulation.

III. Hence, considering the different cases,—

(A.) Suppose the pendulum (which is to be regulated) to go, by its own motion in connexion with its own clock, slower than the regulating clock.

We now want to quicken the rate. Start the clock, therefore, so that the galvanic force acts at No. 1.

By the remark II. 2d, this force will over-accelerate the

rate. In a short time, therefore, we shall have the action at No. 2. Here the rate is quickened in a minor degree, and the place of No. 2 will change till it is quickened exactly in the proper degree. At the same time the arc is increased, *i. e.* the maintaining power is increased, and there is no fear of the clock stopping. This will do.

If we had started the clock for force at No. 5, it would have gone through the stages 4, 3, to 2. This will do, but the process will, perhaps, be a little longer. There is no fear of the clock stopping.

(B.) Suppose the pendulum which is to be regulated to go quicker than the regulating clock.

We now want to retard the rate. Let the force act at No. 5. This will over-retard the rate, and will bring it gradually to the state 4, where the retardation is exactly correct. The maintaining power is increased. This will do.

If the force had acted at No. 1, the rate would have been much accelerated, and we should quickly have had the states 2, 3, 4. There is no fear of the clock stopping.

If we started the clock in the state 7, we might run the risk of stopping it.

IV. Hence the following rule appears to be sufficient, in addition to II. (1st) and (2d):—

Start the clock so that the force acts at either extremity of the swing. In case (A) it will soon come to state 2, and will stop there; in case (B) it will soon come to state 4, and will stop there.

Results of the Observations of Small Planets made with the Transit-Circle; and Eclipses, Occultations, and Transits of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the months of January and February, 1861.

(*Communicated by the Astronomer Royal.*)

(All observations of N.P.D. are corrected for Refraction and Parallax.)

Hebe (6).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Feb. 25	12 57 35·9	11 21 2·54	75 34 52·78
28	12 43 16·3	11 18 30·30	75 4 25·76

Parthenope (11).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Feb. 28	13 7 0·5	11 42 18·41	82 37 18·52

Flora ⑧.

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 2	8 20 15·3	3 10 2·38	78 21 48·23
	3	8 16 39·0	3 10 22·00	78 14 25·92
	5	8 9 33·0	3 11 7·93	77 59 19·92
	8	7 59 8·8	3 12 31·72	77 36 5·73
	9	7 55 44·8	3 13 3·70	77 28 16·07
	11	7 49 2·9	3 14 13·86	77 12 15·58
	21	7 17 22·8	3 21 54·10	75 49 33·06
	29	6 54 7·5	3 30 7·47	74 41 40·86
	31	6 48 25·8	3 32 17·98	74 24 39·52

Melpomene ⑱.

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 2	14 30 42·9	9 21 30·86	81 34 32·86
	3	14 26 11·5	9 20 55·21	81 29 35·69
	5	14 17 3·5	9 19 38·87	81 18 53·23
	7	14 7 50·2	9 18 17·17	81 7 28·94
	8	14 3 10·8	9 17 33·59	81 1 26·13
	9	13 58 30·1	9 16 48·64	80 55 12·67
	21	13 0 46·0	9 6 13·77	79 27 30·10
	29	12 21 16·1	8 58 9·85	78 19 38·07
	Feb. 2	12 1 27·8	8 54 4·51	77 44 25·14
	11	11 17 16·1	8 45 14·56	76 25 24·15
	15	10 57 59·1	8 41 40·61	75 51 37·84
	25	10 11 17·8	8 34 17·13	74 34 2·61
	28	9 57 47·5	8 32 34·32	74 13 12·50

Fides ㊲.

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 2	13 49 50·6	8 40 31·77	66 29 23·42
	3	13 45 6·9	8 39 43·89	66 25 59·54
	7	13 25 59·9	8 36 19·97	66 12 39·09
	8	13 21 9·3	8 35 25·23	66 9 16·08
	9	13 16 18·3	8 34 29·92	66 5 54·26
	21	12 17 6·8	8 22 27·36	65 29 42·79
	28	11 42 26·5	8 15 17·30	65 14 1·19
	29	11 37 31·2	8 14 17·72	65 12 17·67
	Feb. 2	11 17 58·9	8 10 28·42	65 6 1·48
	6	10 58 41·9	8 6 54·52	65 2 9·01
	11	10 35 7·5	8 2 59·02	64 59 47·75

Fortuna (19).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 9	7 25 10·9	2 42 24·80	75 33 44·65

Massilia (20).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 2	10 57 34·7	5 47 47·65	67 45 48·55
	3	10 52 43·4	5 46 52·03	67 46 4·10
	8	10 28 48·2	5 42 35·69	67 47 16·72
	9	10 24 6·1	5 41 49·45	67 47 27·05
	11	10 14 47·5	5 40 22·37	67 47 49·78
	28	9 1 22·5	5 33 46·86	67 47 9·94
	29	8 57 23·8	5 33 44·01	67 46 53·58
	31	8 49 33·4	5 33 45·47	67 46 9·69
	Feb. 2	8 41 52·1	5 33 56·04	67 45 26·40
	6	8 26 56·4	5 34 44·11	67 43 26·54
	11	8 9 7·0	5 36 34·55	67 40 26·93
	15	7 55 28·8	5 38 40·25	67 37 51·14
	18	7 45 36·8	5 40 36·38	67 35 45·50
	27	7 17 39·4	5 48 3·31	67 29 33·29
	28	7 14 41·6	5 49 1·62	67 28 54·77

Lutetia (21).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 8	10 46 9·5	5 59 59·86	65 11 17·11
	21	9 44 33·9	5 49 29·46	65 3 45·52

Proserpine (26).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 29	12 38 45·0	9 15 41·60	68 9 14·21
	Feb. 2	12 19 11·2	9 11 50·77	67 51 19·63
	15	11 15 39·6	8 59 24·03	67 3 4·55

Amphitrite (29).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
		h m s	h m s	° ′ ″
1861,	Jan. 3	7 45 54·3	2 39 32·25	66 4 28·67
	8	7 28 1·9	2 41 19·76	66 7 50·55
	21	6 44 54·4	2 49 20·38	66 3 11·88

No Occultations of Stars by the Moon were observed.

Eclipses, Occultations, and Transits of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1861.			h m s	
Jan. 2	III	Ingress, bisection (*a*)	9 15 22·7	C.
2	I	Occ. reapp. last cont.	12 54 3·7	C.
2	III	Egress, last cont.	12 56 33·3	C.
3	I	Egress, first cont.	9 58 30·7	J. C.
3	I	,, bisection	10 2 30·1	J. C.
3	I	,, last cont.	10 6 29·4	J. C.
9	III	Shad. Ingr. bisection	9 50 7·9	J. C.
9	I	Ecl. disapp.	11 37 46·3	J. C.
9	II	Ingress, bisection	12 23 12·9	J. C.
9	III	Ingress, bisection	12 42 24·8	J. C.
9	III	Shad. Egr. bisection	13 28 2·3	J. C.
11	II	Occ. reapp. first app.	9 55 3·8	C.
11	II	,, last cont.	9 57 3·5	C.
23	II	Ingress, first cont. (*b*)	16 50 19·2	A. D.
23	II	,, bisection (*b*)	16 52 23·9	A. D.
23	II	,, last cont. (*b*)	16 54 23·6	A. D.
Feb. 2	I	Ingress, last cont. (*c*)	9 13 7·4	M. D.
2	I	Egress, first cont.	11 27 45·3	M. D.
2	I	,, last cont.	11 31 44·7	M. D.
6	IV	Ecl. disapp.	8 7 17·9	E.
6	IV	Occ. reapp. bisection	13 46 37·2	E.
6	IV	,, last cont.	13 51 6·5	E.
11	I	Egress, bisection	7 37 26·5	C.
11	I	,, last cont.	7 39 11·2	C.
18	I	Ingress, first cont.	7 3 45·1	A. D.
18	I	,, bisection	7 5 44·7	A. D.
18	I	,, last cont.	7 7 14·5	A. D.
18	I	Egress, bisection	9 24 7·1	A. D.
18	I	,, last cont.	9 26 6·7	A. D.
21	III	Ingress, first cont.	12 7 49·3	K.
21	III	,, bisection	12 10 20·9	K.
21	III	,, last cont.	12 15 20·1	K.
28	III	Ingress, first cont.	11 48 35·4	N.
28	III	,, bisection	11 52 4·8	N.
28	III	,, last cont.	11 54 39·4	N.
28	III	Shad. Ingr. last cont.	13 38 32·4	N.

(*a*), The images very tremulous. (*b*), The limbs of the planet badly defined, especially at the last contact. (*c*), Unsatisfactory.

The initials E., C., J. C., M. D., K., A. D., and N., are those of Messrs. Ellis, Criswick, Carpenter, Dolman, Kerschner, Davis, and Newcomb.

Discovery of Minor Planet (64).

A telegraphic despatch from Marseilles appeared in Le Verrier's *Bulletin* for the 6th of March, announcing this discovery, which, by a subsequent account, proves to be due to M. Tempel. The places given are

	h m		h m s		° ′
March 4	14 40	R.A.	12 3 56	Decl.	−2 5
3	14 11		12 3 11		−2 1

The discovery of the Minor Planet (68) and of the last-mentioned Planet (64) was announced from the Chair by the President.

A third discovery has since followed closely on those just referred to, the account of which is given from Le Verrier's *Bulletin* of March the 10th:—

Discovery of Minor Planet (65).

This planet was also discovered by M. Tempel at Marseilles, in the immediate neighbourhood of (64). The first place given in the despatch is:—

	h m		h m s		° ′ ″
March 9	11 24	R.A.	12 6 19·5	Decl.	+1 1 46

The following positions observed by M. Tempel of the Planets (68) and (64) may be added:—

Minor Planet (68).

	Marseilles M.T.	R.A.	Decl.
	h m s	h m s	° ′ ″
March 2	10 45 31	10 53 8·4	+6 20 9
3	8 55 3	10 52 10	+6 24 12
4	10 31 38	10 51 4	+6 28 43
6	9 47 33	10 49 3	+6 34 41
8	9 53 44	10 47 0	+6 41 19

Minor Planet (64).

	Marseilles M.T.	R.A.	Decl.
	h m s	h m s	° ′ ″
March 4	14 40	12 3 56	−2 5 27
5	14 11 36	12 3 10·8	−2 1 23
6	10 32 8	12 2 31·7	−1 56 53
6	13 46 24	12 2 24·5	−1 56 15
7	11 42 40	12 1 41	−1 51 53
8	10 34 53	12 0 54	−1 48 26

It is not stated, but is probable, that the above places are corrected for refraction, but not for parallax.

On a Method for determining Longitude without Clock. By M. Radau.

In the *Géodésie d'Ethiopie*, par M. D'Abbadie, I have suggested a method for finding the latitude without needing a clock, by means of an altazimuth, and have explained the method of corresponding azimuths, which has been proposed by M. D'Abbadie, and may be used for ascertaining the meridian also without chronometer (see *Astr. Nach.*, No. 1298). But it would seem to be much less easy to find out the longitude in the case where a traveller is deprived of this latter instrument, since the clock is generally considered as being indispensable for such an observation. I, therefore, think it right to communicate a method I have conceived some time ago, which seems to me, when well employed, to answer that purpose in a satisfactory manner. I suppose, at first, the latitude of the place to be already known. It is then possible to obtain the longitude by means of alternate observations of the Moon and a Star, as well in altitude as in azimuth. The Star's altitudes may be used for calculating its azimuths and hour-angles: the former supply the orientation of the Moon's azimuths; the latter afford, with a sufficient degree of accuracy, the time of the mean of the lunar observations, which is wanted for computing a double ephemeris of the Moon's azimuths and altitudes, with two assumed longitudes, l and $l + 100^s$. Hence we may deduce, by interpolation, two systems of altitudes corresponding, in each case, to the observed azimuths of the Moon, and the comparison of these two systems leads to the determination of the true longitude. The correction Δl, which the assumed longitude l has to undergo when the zenith distance z, computed for a given azimuth, differs from observation by Δz seconds in arc, depends upon this formula:—

$$\frac{\Delta l}{\Delta z} = \frac{1 - \alpha}{\nu} \cos q + \frac{\sec \delta}{15} \sin q,$$

where q is the parallactic angle, δ the moon's declination, ν her motion in declination per second, and α that in right ascension (given in time is also the longitude). We shall have, of course, $\frac{1}{\nu} > 4$, $1 - \alpha > 0{\cdot}95$, and $\frac{\sec \delta}{15}$ between 0·07 and 0·08.

It is evident that for those observations the Moon must be near the equator, because, in that case, the quantity ν is considerable enough, and likewise, that it is necessary to observe near the prime vertical, where the angle q is at a maximum. For this latter reason the method is also better suited to tropical countries than to higher latitudes. Besides, it would be well to take the Moon in the east when her declination is increasing (ν pos., sin q neg.) and in the west when it is diminishing (ν neg., sin q pos.). I have had no opportunity

for making a trial of this method, and it would be very satisfactory for me to learn whether observers find it to be advantageous in practice.

Paris, January 1861.

Mr. Nasmyth, in a private letter to Mr. De La Rue, dated 5th Feb. 1861, states that he finds that the entire luminous surface of the sun is resoluble into the most complex superposition of elementary lense-shaped figures, arranged without any approach to symmetrical order in the details, but rather (if the term may be used) in a sort of regular random scattering; the letter was accompanied by a photograph from the original drawing, and an illustrative paper model.

In a letter, dated the 5th March, 1861, Mr. S. Gorton calls attention to the extremely dark appearance of the 3d and 4th Satellites of *Jupiter* in transit over the disk of the Planet, as seen by him and one or two other observers, the transit of the 3d Satellite on the 28th February, and that of the 4th Satellite on the 3d March; and he incloses a copy of his notes of the observations, as also of those of the transit on the 4th March of the 1st Satellite, which was almost invisible on account of its brightness. The dark appearance of the 4th Satellite on the transit of the 3d March is also noticed in a communication from Mr. T. W. Burr, whose account of the observation has, however, appeared in print elsewhere. The phenomenon, as regards both the 3d and 4th Satellites, has been frequently observed, see *Monthly Notices*, vol. xx. pp. 57 and 245, 246.

M. Goldschmidt, in a letter dated the 2d March, 1861, addressed to the Foreign Secretary, expresses his gratitude to the Royal Astronomical Society for the recompense and encouragement given to him by the award of the Medal.

There are contained in the *Comptes Rendus* (t. xlix., p. 673, t. l., p. 474, and t. li., p. 964) notices of a memoir "Sur les Cartes Géographiques," by M. A. Tissot. In the first part the author gives the law of deformation about each point, whatever the system of representation may be; in the second, he compares together those which have been employed or only proposed, for the construction of maps of the world; in the third part he resolves the question,—to find the best mode of

projection for any particular country. There exists an infinity of systems of representation, which do not modify the angles; but in the case of a country such as Russia, of an exceptional extent in all directions, even in selecting the system which reduces to a minimum the greatest variation of distance, the scale would undergo large variations in the extreme portions of the map, unless indeed the country represented be divided into regions having each of them its own map. The following are consequently the most important cases. 1°, a portion of the terrestrial surface of small extent in latitude, but of any extent whatever in longitude; 2°, one of small extent in longitude, but of any extent whatever in latitude; 3°, a country of moderate extent in latitude and longitude, as France, Spain, &c.

Let L be the latitude of any point, L_0 that of a central point, m the longitude of the first point from the second, r the radius of the parallel the latitude whereof is L, r_0 that of the parallel the latitude whereof is L_0, s the arc of meridian comprised between these two parallels, x and y the rectangular coordinates on the map, of the point the latitude whereof is L and longitude m.

In the first case the best system of projection is given by the formulæ

$$(1) \qquad x = S + \frac{1}{2} r m^2 \sin L, \quad y = r m \left(1 + \frac{1}{6} m^2 \cos 2 L\right).$$

In the second case, putting

$$R_0 = r_0 \operatorname{cosec} L_0, \quad R = R_0 - S - \frac{1}{6} S^3, \quad \varphi = m \sin L_0,$$

then the formulæ are

$$(2) \qquad x = R_0 - R \cos \varphi, \quad y = r \sin \varphi.$$

In the third case if N_0 is the great normal of the meridian at the latitude L_0 (? the portion of the normal, intersected between the point on the surface and the polar axis), and if μ denote the variable quantity $m \cos L_0$, then the formulæ are

$$(3) \qquad x = s + \frac{1}{2} N_0 \tan L_0 \mu^2 + \frac{1}{3} A s^3 - B s^2 \mu + C s \mu^2 + \frac{1}{3} B \mu^3,$$

$$y = r m + A s^2 \mu - B s \mu^2 + \frac{1}{3} C \mu^3,$$

where $L - L_0$ may be substituted in the place of s, except in the first term of the expression for x; A, B, C, are constant coefficients, the third of which is connected with the first by the equation

$$2 (A + C) \cos^2 L_0 = \cos 2 L_0,$$

and A and B depend on the form of the contour of the country, and are obtained as follows; first tracing the contour by referring each of its points to two rectangular axes by means of the co-ordinates $L - L_0$, μ, it is easy by a few graphical trials to determine in magnitude and position the enveloping ellipse such that the diameter inclined 45° to the two axes is the least possible. Let $2\,d$ be the length of this minimum diameter, $2\,a$ that of the corresponding major axis, α the inclination of such major axis to the axis of the co-ordinates μ; then

$$(4)\qquad A = \frac{1}{2}\left(\cos^2\alpha - \frac{d^2}{2\,a^2}\cos 2\,\alpha\right),\quad B = \frac{1}{4}\left(1 = \frac{d^2}{a^2}\right)\sin 2\,\alpha,$$

the centre of the ellipse will give the central point of the map, and consequently the latitude L_0, an approximate value whereof will have been sufficient for the purpose of this preliminary construction.

For certain exceptional contours the mode of projection must be somewhat modified. Lastly, there may be introduced on the right-hand sides of the equations (1), (2), and (3), a constant factor which it is easy to determine for each country in particular, and of which the effect is to diminish by one-half the greatest alteration in length, rendering this positive in certain regions and negative in others.

Applied to France, the foregoing researches give

$$(5)\qquad A = 0{\cdot}306,\quad B = 0,\quad C = -0{\cdot}368,\quad L_0 = 41^\circ\,40'$$

and the central meridian is that of Paris. Applied to Spain, the central meridian is that of Madrid, and the central parallel that of 40°; the formulæ are

$$x = s + 0{\cdot}42013\,\mu^2 + 0{\cdot}111\,s^3 - 0{\cdot}185\,s^2\mu,$$
$$y = r\,m + 0{\cdot}333\,s^2\mu - 0{\cdot}062\,\mu^3.$$

A table is given showing, for six different countries, the greatest alteration of angle and the greatest alteration of distance produced by the mode of projection adopted in the construction of the map of France by the Dépôt de la Guerre, and by one of those proposed in the Memoir.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXI. *April* 10, 1861. No. 6.

Dr. Lee, President, in the Chair.

Major Strange, H.M. Indian Army;
Dr. Nottingham, Liverpool;
H. J. S. Smith, Esq., Balliol College, Oxford; and
Lieut. Cuspendale, H.M.I.N.,

were balloted for and duly elected Fellows of the Society.

The twenty-ninth volume of the *Memoirs* is ready for delivery. It contains the longer papers read at the Meetings of the Society, and also the twentieth volume of the *Monthly Notices*, reprinted in a quarto form, thus giving a complete account of the proceedings of the Society during the year. The price is 5*s*. to Fellows, and 15*s*. to the public.

The Astronomische Nachrichten.

The publication of the fifty-fifth volume has recently commenced. The price per volume is 15*s*., payable in advance. Two volumes are generally published in the course of the year. Fellows of the Society desiring to become subscribers may send a notification to that effect to Mr. Williams, the Assistant Secretary of the Society, who will receive the subscription.

On the Morning Illumination of two disrupted Lunar Craters, unnoticed by Webb and unnamed by Beer and Mädler. By W. R. Birt, Esq.

On a few former occasions I have presented to the attention of the Society notices of the morning and evening illuminations of lunar craters, possessing features that withdraw them from the general type of the cup-shaped cavities abounding on the Moon's surface, inasmuch as their rings are incomplete and they are mostly found in localities of a peculiar character, viz., on the borders of the *Maria*, the disrupted portions of the rings being in the cases quoted towards the *Maria*, see *Monthly Notices*, vol. xx. p. 69, *Fracastorius;* p. 211, *Hippalus;* and p. 280, *Schröter's Newton.*

On the evening of March 22, 1861, between $6^h\ 50^m$ and $9^h\ 15^m$ G.M.T., I had an opportunity of observing the southern part of the *Mare Humorum*, then under an early morning illumination; the eastern portion, with the mountains composing it, being observed beyond the terminator as splendid lucid points. *Gassendi* was a most magnificent object, the atmosphere being in a fine state for definition, many minute features were brought out not ordinarily discernible.

The two craters marked on Beer and Mädler's map, and also on Webb's index map, 229 and 230, as abutting on the southern part of the *Mare Humorum*, are *Vitello* and *Doppelmayer*. The first, *Vitello*, is a perfectly ringed crater, with a central mountain of somewhat considerable dimensions, it is seen under this illumination to rise magnificently from the floor of the crater, the shadow of the western wall partially surrounding its base.

The second, *Doppelmayer*, is an imperfectly ringed crater, the imperfection indicating a destruction of the mountains that formed this part of the wall, being, as in the cases already quoted, *towards the Mare.* This crater has a central mountain, casting at this epoch a long shadow towards the eastern part of the ring.

Between these craters, and filling the entire space, are the remains of a large crater, having to the south-east a smaller one, the level of the larger partially destroyed crater appearing to be slightly depressed below the level of the adjoining portion of the *Mare.*

On the western margin this larger crater does not appear under this illumination to possess a wall proper to itself, but at an epoch about 24 hours later, as seen on March $23^d\ 8^h\ 20^m$, the illumination then brings out very distinctly its western wall, just touching the wall of *Vitello* and extending each way, on the north to the abrupt termination of the broken wall, where it meets the general level of the *Mare*, and on the south to the abrupt termination of the broken wall of the smaller crater to the south-east. The interior shadows of the western

walls of both craters are well marked at the later epoch, and the original outline of the larger crater traced by means of a few scattered peaks, or rather blocks, to its junction with the wall of *Doppelmayer*, where that also is broken by the disruptive force which appears to have acted simultaneously on the three craters.* Under this illumination *Doppelmayer* offers a fine example of the action of this overspreading force, the north-west part *towards the Mare*, within a portion of the standing walls, as far as the central mountain, presenting a slightly greenish grey appearance, while the other half of the crater remains in its original, or at least former state, the contrast of the two being very decided. The illumination at about 12·25 days of the Moon's age is much more suitable for bringing out the features of the partial destruction of the walls of the three craters than the earlier illumination at 11·25 days, it is then that the eastern wall of *Vitello* with its sharp curvature casting a deep and extensive shadow on the western portion of the floor of the large disrupted crater suggests the idea that *Vitello* is a more recent crater than either *Doppelmayer* or the large unnamed crater.

A little to the south-east of this large disrupted crater I observed a smaller one, the south-east portion of its ring being *exterior* to what may be considered the south-east boundary of the larger crater, which evidently appears to have been torn away. A ridge extending between the walls of the smaller crater and *Doppelmayer* gives a certain feature of angularity to the rampart composed of the walls of the two craters and the included ridge; and this is so marked as (in addition to the position of the smaller crater, indicating its more recent formation, being partly on and partly off the area of the larger crater), also to confirm the idea of the different epochs of the origin of the two.

While the wall of the smaller crater is complete on the south and south-east, its northern portion has been partially destroyed; in this respect it agrees very closely with the features presented by the larger crater, the whole of the walls of which, except those mentioned above, having been destroyed; a few peaks remain on the northern ring of the smaller crater, which thus has some affinity with the crater *Fracastorius*. The south-west portion of the ring casts a deep shadow on the floor, which appears to be of a rather lower level than the crater on which it partly stands.

It will be seen, on referring to the *Monthly Notices*, vol. xx. p. 211, that *Hippalus* is situated on the north-west border of an arm of the *Mare Humŏrum*, and that the disrupted portion

* At the *earliest* epoch of illumination of the large disrupted crater, viz., about 10·6 days of the moon's age, and about 2·6 days after the epoch of greatest south-east libration, I have seen the circular outline of its ring nearly complete, the blocks mentioned in the text catching the first rays of the rising sun.

faces this arm. On viewing these features that are thus common to the disrupted craters situated on the borders of this *Mare*, one almost feels disposed to venture a conjecture that here we have the means of approximating to the successive ages of some of the crateriform productions on the lunar surface. "Every thing which tends to throw light on the manner in which the inequalities on the Moon's surface have originated," says Arago, "is eminently deserving of attention." Taking *Doppelmayer*, south-east, and *Hippalus*, north-west, we have evidence of the disruptive force existing between them, in fact extending south-eastward, south-westward, and north-westward. Has this force any connexion with the overspreading of the *Mare* with its plain-like covering? Assuming for a moment that such is the case, we do not know that it is so, we have the two craters named with the two unnamed more ancient than the overspreading of the *Mare* itself—the small unnamed crater being more recent than the one near which it stands and which it partially covers, and probably more recent than the other three. The age of *Vitello*—with its still perfect walls closely adjoining as they do the western flank of the large unnamed crater—more recent than the period of the overspreading of the *Mare;* and the magnificent *Gassendi*, also more recent than this period, probably marking an epoch, the most recent of the violent outbursts which produced such magnificent craters as the one just named, *Copernicus, Tycho, Plato*, and several others which appear to be most perfect, *Copernicus* having suffered considerably from degradating agencies.

On an Appearance on the Surface of Jupiter, which passed rapidly over the Disk of the Planet. By W. R. Birt, Esq.

On the 22d of March, 1861, at about $7^h\ 20^m$ G.M.T., I noticed near the eastern limb of *Jupiter* a difference in the breadth of the northern belt, a small portion near the limb was about half the breadth of the remainder, which extended to near the western limb, the termination of the half-breadth of the broadest was rugged and irregular; about 40 minutes later, viz. at 8^h, this ragged portion occupied the centre of the disk with a somewhat dark spot near its termination. At $9^h\ 15^m$ this portion had arrived within a tenth of the longest diameter of the disk from the western limb. When next I noticed *Jupiter* it was gone, and he had two well-defined narrow belts; at 11^h I observed a fine line-like belt just north of the narrow belt.

Was this an instance of a rapid propagation of cloud in the atmosphere of the planet?

Observations of Saturn. By Warren De La Rue, Esq.

While observing *Saturn* during the last few weeks my attention has been attracted by the very irregular outline of the shadow crossing the planet's northern hemisphere just above the inner dark ring. I noticed this very distinctly on the night of the 7th instant, when my 13-inch Newtonian Equatoreal bore a power of 700 perfectly well. On that and other occasions I scrutinised the planet with a very beautiful achromatic by Dallmeyer (the late Mr. Ross's son-in-law) of $4\frac{1}{8}$ inches aperture, and I noticed the same appearance, so that

astronomers possessing instruments of moderate size may observe the phenomenon provided they define perfectly. It is right to mention that the achromatic I refer to shows the 5th and 6th stars in the trapezium of *Orion*, and that on a clear night I even made out *Enceladus*, having first observed it, however, with the 13-inch reflector.

Cranford, April 11, 1861.

Photographs of the Total Eclipse.
By Warren De La Rue, Esq.

I am desirous of an opportunity of making known to Astronomers that some further delay will take place before copies of the two totality pictures can be printed off for circulation. In order to show the details of the protuberances it is necessary to enlarge the copies to about 9 inches in diameter, and from these to make a sufficient number of negatives to print the paper copies it is proposed to publish.

A few perfect positives were obtained soon after the return of the Himalaya Expedition from Spain, but they have been used up in making the engraved plates in the manner already made known to the Society. Since the size of the intended volume of Reports has been settled by the Astronomer Royal, several attempts have been made to procure the positive transparent enlarged copies, which will serve to make the negatives to print from, but hitherto without success, in consequence of the want of favourable weather. Up to yesterday all attempts to multiply copies have failed, for nothing short of an unobscured brilliant Sun will penetrate the dense original negatives so as to show the details of the protuberances; after spending 21 days in fruitless attempts I have come to the conclusion that it will be better to defer for a few weeks longer any further trials. An exposure of 40 to 45 seconds suffices in brilliant sunlight to produce a perfect picture, but an exposure of 15 minutes fails to produce a picture worthy of circulation when the Sun is obscured by the mists which have been prevalent.

Cranford, April 11, 1861.

On a Micrometric Diaphragm. By L. H. Casella.

The impulse given of late to the study of solar physics by the accurate series of observations on the Solar Spots by Mr. Carrington, Dr. Wolfe, Schwabe, and others, is greatly calculated to enlist the energies of amateurs, and many a series of diagrams of the Solar Disk might be constructed, were a simple and easy method of obtaining the position of those spots readily attainable.

About two years since I constructed for Mr. Birt a micrometric diaphragm, which appears so suitable for obtaining approximate positions of the spots as to induce me to submit it to the attention of the Society, especially as I consider it will enable an observer, from a series of observations only, to lay down diagrams of the spots from day to day, which may be compared at leisure, and from which several questions may be approximately answered by many in whose hands the employment of more delicate instruments or methods with the calculations attendant on them would in a great measure prevent.

The diaphragm is of glass, fitted to the focus of the eye-piece, and engraved with equidistant parallel lines dividing the field into about thirty-five divisions, each line terminating a little beyond the transverse diameter of the field, except every fifth line, which extends quite across the field.

The value of each division can easily be ascertained in the usual way.

In observing the position of a spot, the upper or lower limb of the Sun is made to run along the lowest or highest line that stretches across the field; when this is nicely adjusted the spot is seen to traverse the field either on a line or somewhere between two, the proper adjustment being known by the spot keeping on a given line or being equally distant from the lines above and below it throughout its transit: it is then easy to see the number of divisions, and by estimating the parts of a division by which the spot is distant from the limb, tenths can be readily estimated and the approximate diameters of spots easily determined.

When the positions of all the spots visible are determined from the upper or lower limbs, the diaphragm is shifted a quarter of a revolution by simply turning the eye-piece in the tube, and each spot in succession is made to run along the extremities of the shorter lines. As the spots transit each line, so the preceding and following limbs also transit each line, and the remaining co-ordinate is determined by the number of divisions and parts by which the spot follows the preceding, or precedes the following limb.

Not only is the diaphragm suitable for obtaining these positions approximately to about 6″, but it is also useful for readily laying down groups, the observer being prepared with paper ruled in squares on a large scale, when the co-ordinates of the principal members of the group are obtained as above. The minor spots may be inserted in their proper places in the manner of sketching; a little practice will soon enable an observer to lay down all the features of a group within the limits above indicated.

Extract of a Letter from Dr. Winnecke to the Rev. R. Main, dated 1861, *March* 26.

"In No. 3 (of the *Monthly Notices*) Mr. Carrington brings forward the question concerning the figure of the sun—would it not be desirable to remind the Astronomical Society, on this opportunity of the measures made by Schlüter and Wichmann with the Königsberg heliometer, which, although they have fallen into oblivion, seem to determine the question for the present position of the science of observation? Schlüter observed the sun on five days in such a way as to make one measured diameter pass through the pole, while the other was at right angles to it. For this purpose he prepared an ephe-

eris computed for the position of the sun's equator at that me. The following are the values obtained:

	Angle of Position of Pole.	Polar Diameter.	Equatoreal Diameter.
	° ′	′ ″	′ ″
1842, Oct. 22	334 17	31 60·30	31 60·09
1843, Feb. 28	21 36	59·82	59·41
,, March 17	24 56	59·59	59·75
,, March 21	25 27	59·96	60·06
,, June 4	14 9	59·96	60·33

Therefore the equatoreal diameters are greater by,

″
−0·21
−0·41
+0·16
+0·10
+0·37

from whence in the mean there is perfect equality between the equatoreal and polar diameters.

"Nearly the same result is arrived at from measures made at the same place (*Königsberg Observations*, Part 30), in which diameters differing by angles of position amounting to 30° were employed.

"The diameter given above does not differ materially from that commonly received, as deduced from meridian observations. For the reduction of a series of meridian observations there has been for security employed that diameter of the Sun, deduced from the observations themselves, which corresponds to the instrument and the observer. But, when the question is to employ the true value of the diameter, there is no doubt that that which is derived from the observations made with the Königsberg heliometer deserves the preference. For no other instrument is the entire freedom from irradiation so evidently proved as for the Königsberg heliometer. The inequalities of the screw, and the value of one of its revolutions, have been investigated in an incomparable manner.

"The only thing which could have been wished for more in the preceding measures consists in the want of a satisfactory explanation of the external circumstances under which these observations were made. According to Schlüter's account it would appear as if he always observed with a sky densely covered, so that an anomalous heating of the object-glass and of the screws (the latter of which in particular were protected by white paper placed before them) is not to be feared. In Wichmann's observations this has not been always the case, so that Schlüter's results without doubt deserve the preference.

"Besides this, the intimation that possibly the thermometer-coefficient for the value of a revolution of a screw has not been taken into account with sufficient accuracy, has plainly a relation only to the absolute value of the diameter, without in the least affecting the conclusions respecting the figure of the Sun."

Observations of the Solar Eclipse of the 11th Jan., 1861, *at the Sydney Observatory.* By W. R. Scott, Esq., Astronomer for N. S. Wales.

In a letter dated February 19th, 1861, addressed to the Secretary, Mr. Scott writes:—

"I send herewith the results of my observations of the solar eclipse of January 11th.

"The eclipse was observed with the portable equatoreal telescope, 3¼ inches aperture. I obtained measurements of some chords, but cannot attach any value to them, owing to great instability of the mounting.

"The most accurate observation was the time of first contact of the Moon's limb with the first of two very black well-defined spots in the midst of a group of less defined spots.

"I regret that I was unable to leave the Observatory so as to visit a part of the colony where the eclipse was annular; neither have I received reports of any observations of the annular eclipse.

"The temperature observations were made with a black-bulb thermometer in an exhausted glass tube.

"I give the results from 1^h P.M., having reason to believe that those made before that time were not trustworthy.

"I am happy to state that I have reason to hope shortly to be enabled to produce some better work than the defective character of my instrumental means has hitherto allowed; as an equatoreal telescope by Mertz, with a 9-inch object-glass, is on its way from England.

"Being somewhat of a novice in practical astronomy, and isolated from the rest of the astronomical world, I shall feel grateful for any suggestions from your Society as to the best mode of co-operating (when my new instrument arrives) with the astronomers of Europe and America."

The observations referred to in the letter are,—

	Syd. M.T. h m s
Commencement of Eclipse, Jan. 11	0 38 14
Contact with spot	0 53 20
End of Eclipse	3 28 15

Observations with black-bulb thermometer,

h m	°	h m	°
1 0	125·6	2 25	96·0
1 15	117·5	2 30	97·6
1 20	113·8	2 35	98·4
1 25	112·0	2 40	100·0
1 30	110·5	2 45	102·0
1 35	107·0	2 50	104·0
1 40	104·8	2 55	106·7
1 45	103·6	3 0	109·7
1 50	100·3	3 5	112·6
1 55	98·8	3 10	115·5
2 0	97·7	3 15	117·3
2 5	96·6	3 20	119·0
2 10	95·3	3 25	121·1
2 15	95·0	3 30	121·2
2 20	94·8		

The sky was perfectly clear throughout.

Note on one of the Comites of β Geminorum. By the Rev. T. W. Webb.

On reference to the Bedford Catalogue, it will be found that the third attendant of *β Geminorum* was described by Admiral Smyth, in 1832, as of equal brightness with the second, C of his nomenclature, which he rates of $11\frac{1}{2}$ magnitude. It now appears, with my $5\frac{1}{2}$-inch object-glass, about as much inferior to B, $12\frac{1}{2}$ of the Admiral's scale, as B is below C; and as Sir James South's Equatoreal of 5 inches had shown but two companions some years before the date of the Bedford Catalogue, there is, perhaps, ground to suspect a variation in its light.

Hardwick Parsonage, April 22, 1861.

Results of the Observations of Small Planets made with the Transit-circle; Occultations of Stars by the Moon; and Eclipses, Occultations, and Transits of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of March 1861.

(*Communicated by the Astronomer Royal.*)

Massilia (20).

Mean Solar Time of Observation.		R. A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 4	7 3 5·9	5 53 10·15	67 26 37·61

Hebe (6).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 4	12 24 5·5	11 15 2·54	74 24 53·51
6	12 14 28·6	11 13 17·20	74 5 37·00
9	12 0 3·6	11 10 39·41	73 37 58·80
11	11 50 27·9	11 8 55·24	73 20 12·72
13	11 40 53·3	11 7 12·26	73 3 5·89
16	11 26 34·5	11 4 40·69	72 38 49·60
20	11 7 37·7	11 1 27·06	72 9 10·61
21	11 2 55·8	11 0 40·92	72 2 20·34
22	10 58 14·1	10 59 55·00	71 55 39·41
28	10 30 25·2	10 55 40·86	71 20 8·45

Parthenope (11).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 4	12 47 59·4	11 39 0·35	82 8 19·67
6	12 38 24·6	11 37 17·06	81 53 59·27
8	12 28 48·4	11 35 32·45	81 39 37·24
9	12 23 59·0	11 34 38·78	81 32 23·87
11	12 15 21·4	11 32 52·91	81 18 16·04
13	12 4 43·4	11 31 6·23	81 4 17·68
16	11 50 16·0	11 28 26·07	80 43 55·15
20	11 31 2·7	11 24 55·90	80 18 7·69
21	11 26 15·9	11 24 4·79	80 11 58·35

Melpomene (18).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 4	9 40 10·4	8 30 40·50	73 47 24·79
6	9 31 32·4	8 29 54·18	73 35 16·72
8	9 23 1·6	8 29 15·08	73 23 46·91
11	9 10 28·5	8 28 29·56	73 7 40·80
13	9 2 15·7	8 28 8·51	72 57 42·31
21	8 30 34·9	8 27 54·96	72 23 50·57
22	8 26 45·0	8 28 1·02	72 20 21·47
23	8 22 57·0	8 28 8·89	72 16 55·16
28	8 4 20·4	8 29 11·99	72 2 1·79

Fides (37).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 8	8 48 23·5	7 54 31·35	65 28 40·92
16	8 18 23·0	7 55 58·33	65 49 21·15

Ausonia (63).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 15	11 5 55·2	10 40 1·43	82 55 2·74
16	11 1 2·9	10 39 4·94	82 52 2·07

Angelina (64).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, March 15	11 51 58·3	11 49 51·45	90 43 18·14
22	11 47 11·6	11 49 0·53	90 38 11·56

The observations in N.P.D. of *Ausonia* and *Angelina* have been corrected for Refraction only; those of all the others for both Refraction and Parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			h m s	
1861, Mar. 19	5 Geminorum disapp.	Dark	8 53 55·4	D.
21	B.A.C. 2683 disapp.	Dark	9 43 39·3	C.
21	B.A.C. 2683 reapp. (*a*)	Bright	10 20 7·4	C.

(*a*), The star was slightly separated from the limb when first seen.

The initials D. and C. are those of Mr. Dunkin and Mr. Criswick.

Eclipses, Occultations, and Transits of Jupiter's Satellites.

Day of Observation. 1861.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
			h m s	
Mar. 4	III	Ecl. reapp.	7 23 17·0	A. D.
4	I	Ingress, Bisection	10 35 59·6	J. C.
4	I	,, last cont.	10 38 29·2	J. C.
4	I	Egress, last cont.	12 57 32·3	A. D.
6	I	,, bisection	7 20 26·8	K.
6	I	,, last cont.	7 22 26·5	K.
11	III	Ecl. reapp.	11 21 15·1	E.
11	I	Ingress, bisection	12 20 25·4	E.
11	IV	Occ. disapp. bis.	13 31 43·8	E.
16	II	Ecl. reapp.	7 57 59·9	E.
21	I	Ecl. reapp.	8 52 17·7	C.
21	II	Ingress, bis. (*a*)	10 55 49·4	C.
28	IV	Occ. reapp. bis.	9 38 1·6	E

(*a*) The planet extremely tremulous and blurred; the observation v unsatisfactory.

The initials E., C., J. C., K. and A. D. are those of Messrs. Ellis, Crisv Carpenter, Kerschner, and Davis.

Note.—In the *Monthly Notices* for June, 1860, vol. xx., No. 8, p. 328, the places of two objects are given for *Thetis*, with the remark that their proximity made it doubtful which was the planet, though the second was thought to have the greater probability, on account of its magnitude. That this second, marked (*b*) R.A. $14^h\ 3^m\ 52^s{\cdot}32$, N.P.D. $92°\ 40'\ 11''{\cdot}98$, really was *Thetis*, was proved by an observation with the transit-circle on 1861, April 11, when an object was seen answering to (*a*), but nothing in the place of (*b*).

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield, Sussex. By Capt. W. Noble.

Sunday, February 17, 1861.

Occultation of 23 *Tauri* by the Moon.

The star disappeared instantaneously at the Moon's dark limb at $7^h\ 51^m\ 7^s{\cdot}7$ L.S.T. = $9^h\ 52^m\ 59^s{\cdot}75$ L.M.T.

Owing to the dense haze, the reappearance could not be observed.

Power 135 (with positive eye-piece) adjusted on the star.

Thursday, March 21, 1861.

Occultation of B.A.C. 2683 by the Moon.

	h m s		h m s	
The star disappeared instantaneously at the Moon's dark limb at	9 43 11·4	L.S.T. =	9 45 39·05	L.M.T.
and reappeared at..........	10 17 46·6	L.S.T. =	10 20 8·58	L.M.T.

It was very faint at its reappearance, owing to the overpowering brightness of the Moon, and the time of its apparition may therefore be $+0^s{\cdot}5$ in error.

Power 115 adjusted on the star.

My 4·2 inches Equatoreal was employed in each observation.

In a letter to Mr. Carrington, dated 11th April, 1861, Capt. Noble writes :—

"Inasmuch as I think that every abnormal circumstance, however trivial, should be placed upon record, I may tell you that while examining the Sun on Thursday, March 28th, at $2^h\,30^m$ G.M.T., with a power of 74, I found that the carefully determined solar focal length of the object-glass, with the eye-piece employed, was *shortened* exactly 0·11 inch! There was a good deal of haze about at the time. The barometer stood at $29^{in}\cdot340$, and the thermometers outside of the observatory at 55°. I can find no notice in any work to which I have access of this curious phenomenon of a considerable alteration in the focal length of a telescope, nor can I presume to theorise upon the matter. The quantity by which the focus was changed was too great to have had its origin in any unusual condition of my own eye; besides which, when the sky cleared, the focus lengthened again to its standard distance. It seems to me that in such alteration we have an explanation of a fertile source of many discrepancies which occur in accounts of the same phenomenon as viewed by different observers, and perhaps even a better one of the inconsistency of observations made by the same individual."

Observations and Elements of Comet III. 1860. By Dr. C. G. Moesta, Director of the National Observatory of Santiago de Chile.

I enclose some observations of Comet III., 1860, seen by me for the first time on the evening of July 10th, and which has been observed here on several nights until the 13th of September. Most of the comparison-stars are probably not to be found in the Catalogues of southern stars, and I intend to determine their positions by the Meridian-Circle as soon as the season will permit it. On the 13th of August the Comet was compared with ν and κ *Centauri*, and on the 12th of September with Taylor 8002. Adopting the positions of these stars, such as they are given in the B.A.C. and Taylor's Catalogue, I obtained the following positions of the Comet:

	G.M.T.	App. R.A.	App. Decl.
	h m s	h m s	° ′ ″
August 13	14 43 8·7	13 47 26·92	−40 19 32·8
September 12	12 48 30·8	15 2 50·64	−47 24 1·6

With approximate elements I formed a normal place of the three observations made at Bonn and Altona (*Ast. Nach.* No. 1266), and after having applied the corrections for parallax and aberration, and reducing all observations to the mean equator for 1860·0, I collected the following places of the Comet:

G.M.T.			R.A. h m s	Decl. ° ′ ″
Altona and Bonn,	June	23·50000	6 45 40·12	+42 18 45·6
Washington,	July	14·56297	10 59 11·56	− 1 4 7·5
Santiago,	Aug.	13·60642	13 47 24·98	−40 19 9·7
Santiago,	Sept.	12·52198	15 2 48·07	−47 23 38·5

The observation of July 14th (*Ast. Nach.* No. 1273) is based upon the following position of Weisse X, 1099, as determined by me with the Meridian Circle:

For 1860·0.

Mean R.A. $= 11^h\ 1^m\ 7^s{\cdot}76$, Decl. $= -1^\circ\ 8'\ 44''{\cdot}4$

By variation of the distances of the Comet from the Sun I found the adjoined parabolic elements, which represent the first and last of the given places, leaving the following errors in the middle places,—

	O − C. δ long. ″	O − C. δ lat. ″
Washington, July 14	−7·1	− 2·5
Santiago, August 14	+6·7	−12·4

Elements.

$$T = 1860, \text{ June } 16{\cdot}05950 \text{ G.M.T.}$$

$$\left.\begin{aligned} ☊ &= 84^\circ\ 40'\ 3''{\cdot}8 \\ \pi &= 161\ 31\ 59{\cdot}3 \end{aligned}\right\} \text{Mean Eq., } 1860{\cdot}0.$$

$$i = 79\ 18\ 33{\cdot}76$$

$$\text{Log } q = 9{\cdot}4667171.$$

Motion direct.

It appears, therefore, that a parabola will represent very well the observations during three months, and that the excentricity of the orbit must be very nearly equal to unity.

Santiago de Chile, Feb. 17, 1861.

Ephemeris of the Variable Stars for 1861. By Norman Robert Pogson, Esq., Director of the Madras Observatory.

In this ephemeris the initials in the sixth column represent the following names:—A., Argelander; B., Baxendell; K., Krüger; P., Pogson; S., Schönfeld; W., Winnecke.

Star.	Probable Mag.	Mean Place, 1860. R.A.	N.P.D.	Times of Maxima.	Authority.
		h m s	° ′		
T Piscium	9·5	0 24 46	76 14	Feb. 17, July 10, Nov. 30 ...	S.
α Cassiopeiæ	2·0	0 32 35	34 14	Feb. 18, May 8, July 26, Oct. 13, Dec. 31	A.
R Arietis	8·0	2 8 10	65 36	Jan. 23, July 28	W. & B.
ο Ceti	2·0	2 12 17	93 37	August 6	A.
R Tauri	8·0	4 20 38	80 9	June 15	W.
S Tauri	10·0	4 21 32	80 22	February 27	W.
R Orionis	9·0	4 51 22	82 5	June 6	—
α Orionis	1·0	5 47 36	82 37	June 28	—
R Geminorum	7·3	6 58 56	67 5	January 19	P.
R Can. Min.	8·0	7 1 0	79 46	April? Uncertain	—
S Can. Min.	7·5	7 25 7	81 23	July 28	W.
S Geminorum	9·2	7 34 38	66 13	Jan. 5, Oct. 26	P.
T Geminorum	8·9	7 40 54	65 55	July 28	—
U Geminorum	9·1	7 46 48	67 38	April 5, July 11, Oct. 16 ...	—
R Cancri	6·0	8 8 51	77 51	Between Feb. 15 and April 23	B. & A.
U Cancri	9·0	8 27 45	70 37	August 31	W.
S Hydræ	8·5	8 46 16	86 24	May 10	—
T Cancri	12·0	8 48 40	69 37	At minimum, Sept. 28 ...	—
T Hydræ	6·5	8 48 51	98 37	May 6	—
R Leonis	5·0	9 40 2	77 55	Jan. 2, Nov. 22. At minimum, July 9	P.
R Urs. Maj.	7·0	10 34 41	20 29	July 1. At minimum, March 10	P.
T Leonis	9·0	11 3 36	83 47	Jan. 5, July 24	W.
R Comæ	8·0	11 57 4	70 26	October 8	—
R Virginis	6·5	12 31 24	82 14	March 16, Aug. 9	A.
S Urs. Maj.	7·5	12 37 48	28 8	Jan. 14, Aug. 28. At minimum, May 21	P.
U Virginis	7·5	12 44 0	83 41	May 30, Dec. 28	W.
V Virginis	7·0	13 20 36	92 28	July	P.
R Hydræ	4·0	13 22 4	112 33	Nov. 15. At minimum, Oct. 30	W.
S Virginis	6·0	13 25 42	96 28	May 8	P.
R Boötis	8·0	14 31 1	62 39	July 6	W.

.	Probable Mag.	Mean Place, 1860. R.A. h m s	N.P.D. ° ′	Times of Maxima.	Authority.
ntis	8·0	15 15 7	75 11	March 11	A.
ose	6·2	15 42 49	61 25	Between July 12 and Sept. 30	A. & B.
entis	6·5	15 44 15	74 26	August 23	A.
e	9·0	15 45 40	105 49	Probably not during 1861 ...	P.
ulis	8·5	15 59 56	71 15	Feb. 12, Dec. 19	W. & B.
ɔii	9·0	16 9 19	112 35	Not during 1861	P.
ii	9·5	16 9 20	112 33	April 19	—
ıchi	9·3	16 26 12	106 52	April 27, Dec. 16 ...	—
ılis	7·5	16 45 32	74 49	Jan. 13, Nov. 14	B.
uchi	7·6	16 59 44	105 54	August 28	P.
ılis	3·0	17 8 16	75 27	Feb. 5, April 13, June 18, Aug. 24, Oct. 29	A.
ulis	7·9	18 3 48	59 0	April 30, Oct. 7	K.
	5·0	18 40 1	95 50	Jan. 14, March 27, June 6, Aug. 17, Oct. 28	A.
e	4·3	18 51 4	46 14	Jan. 25, March 13, April 28, June 14, July 30, Sept. 15, Oct. 31, Dec. 16	B.
læ	6·5	18 59 38	81 59	May 26	A.
tarii	8·2	19 8 28	109 33	February? Irregular ...	P.
i	8·0	19 33 4	40 7	Sept. 23. At minimum, April 21	—
i	5·0	19 45 11	57 27	April 20	A.
icorni	9·5	20 3 28	104 41	September 30	W.
icorni	10·5	20 40 22	105 18	February	P.
eculæ	8·0	20 58 10	66 44	Feb. 11, June 21, Oct. 29 ...	W.
icorni	9·0	21 14 13	105 45	Jan. 24, Oct. 25	S.
si	8·5	22 59 37	80 14	April 15	A.
ırii	7·0	23 37 15	106 3	June 13	—
iopeiæ	6·0	23 51 18	39 23	Sept. 4. At minimum, March 20	P.

Minima of the Short-Period Variable Stars during 1861 *in G.M.T., and for the Earth's Mean Distance from each Star.*

Algol.

Maximum 2·3; Minimum 4·0. Whole variation completed in seven hours.

	d	h	m		d	h	m		d	h	m		d	h	m
Jan.	3	16	50	Jan.	23	18	32	Feb.	4	5	48	Feb.	24	7	30
	6	13	39		26	15	21		15	17	3	Mar.	10	15	34
	9	10	28		29	12	10		18	13	52		13	12	23
	12	7	17	Feb.	1	8	59		21	10	41		16	9	12

	d	h	m		d	h	m		d	h	m		d	h	m
April	2	14	5	June	27	14	31	Sept.	21	14	57	Nov.	12	5	37
	5	10	54		30	11	20		24	11	46		23	16	52
	8	7	43	July	20	13	2		27	8	35		26	13	41
	22	15	47		23	9	51	Oct.	11	16	39		29	10	30
	25	12	36	Aug.	9	14	44		14	13	28	Dec.	2	7	19
	28	9	25		12	11	33		17	10	17		5	4	7
May	15	14	18		15	8	22		20	7	6		13	18	34
	18	11	7		29	16	26	Oct.	31	18	21		16	15	23
	21	7	56	Sept.	1	13	15	Nov.	3	15	10		19	12	12
June	7	12	49		4	10	4		6	11	59		22	9	1
	0	9	38		7	6	53		9	8	48		25	5	50

λ Tauri.

Maximum 4·0
Minimum 4·5
Variation rapid.

	d	h	m
Jan.	1	13	4
	5	11	57
	9	10	49
	13	9	41
	17	8	33
	21	7	25
	25	6	18
April	14	7	41
Aug.	30	16	28
Sept.	3	15	0
	7	13	53
	11	12	45
	15	11	37
	19	10	29
Nov.	17	17	32
	21	16	24
	25	15	17
	29	14	9
Dec.	3	13	1
	7	11	53
	11	10	45
	15	9	38
	19	8	30
	23	7	22
	27	6	14

ζ Geminorum.

Maximum 3·8
Minimum 4·5
Increasing $5^d\,6^h$.

	d	h	m
Jan.	9	15	0
Feb.	19	6	12
Mar.	1	10	0
	11	13	48
May	1	8	48
Sept.	20	14	0
Nov.	10	9	0
	20	12	48
	30	16	36

S Cancri.

Maximum 8·0
Minimum 10·5
Variation rapid.
R.A. $8^h\,35^m\,56^s$
N.P.D. $70^\circ\,28'$.

	d	h	m
Jan.	6	10	4
	25	9	18
Feb.	13	8	32
Mar.	4	7	46
Dec.	4	8	36
	23	7	50

β Lyræ.

Principal Minimum 4·3

First Maximum (3·4) 3^d 2^h after Min.
Second Minimum (3·8) 6 9 ,, ,,
Second Maximum (3·4) 9 10 ,, ,,

	d	h	m
Jan.	8	16	31
June	12	13	34
	25	11	19
July	8	9	4
Nov.	14	10	36
	27	8	21
Dec.	10	6	6

η Aquilæ.

Maximum 3·6
Minimum 4·4
Increasing 2^d 9^h.

	d	h	m
Feb.	16	18	7
	24	15	17
	29	12	28
June	11	13	52
July	17	11	2
	24	15	16
Aug.	22	8	13
	29	12	27
Oct.	4	9	37
Nov.	9	6	47
Dec.	15	3	58

δ Cephei.

Maximum 3·7
Minimum 4·8
Increasing 1^d 14^h.

	d	h	m
Jan.	3	12	34
	14	6	9
	19	14	57
	30	8	32
Feb.	15	10	55
Mar.	3	13	18
	14	6	54
	19	15	41
	30	9	17
April	15	11	40
May	1	14	3
	28	10	1
June	13	12	24
	29	14	47
July	26	10	45
Aug.	11	13	8
Sept.	7	9	7
	23	11	30
Oct.	9	13	53
	20	7	28
Nov.	5	9	51
	21	12	14
Dec.	2	5	49
	7	14	37
	18	8	12

The corrections to be applied to the observed times before comparing with the Ephemeris may be found by the formulæ in the *Monthly Notices*, vol. xvii. p. 27.

The Ephemeris is, for the most part, based upon the same elements of variation as that of last year. For some of the stars, however, I am indebted to Mr. Baxendell and Dr. Winnecke for their valuable contributions of more correct times than I could otherwise have supplied. In a few cases, when two authorities were nearly coincident, the mean has been adopted; or when widely different, both have been given, as limits.

I have again to express my deep regret at the delay of this annual paper, caused by my unforeseen change of position and all its attendant hindrances; but I will endeavour to supply the Ephemeris for 1862 before the close of the current year.

The Hartwell Variable Star Atlas, commenced and far

advanced during my two years' management of Dr. Lee's Observatory, in England, has of course suffered a temporary check, but will be continued and completed here as speedily as possible.

I find I have overlooked one star recently discovered by Mr. Baxendell, and called by him R *Sagittæ*. Its place for 1860 is R.A. $20^h\ 7^m\ 40^s$, N.P.D. $73^\circ\ 42'$; its range of variation from 8·4 to 10·2 magnitudes; and its minimum, in the present year, will be due on March 10, May 21, July 31, Oct. 11, Dec. 21.

Madras Observatory, 1861, *March* 27.

Discovery of a New Comet.

The following observations have been made at this Observatory, by Mr. Ferguson, of a Comet discovered on the night of the 4th of the present month, at the Observatory of Mr. Rutherford in New York, by Mr. A. E. Thatcher.

	M.T. Washington. h m s	R.A. h m s	Decl. ° ′ ″
April 10	10 10 20·6	17 7 56·71	+59 26 13·53
11	8 38 9·5	17 2 32·55	+60 7 20·53

The Comet is circular; about two minutes in diameter, condensed at the centre, and with some appearance of a nucleus.

Observatory, Washington, April 12, 1861.

The Astronomer Royal has received from Mr. Thatcher, by letter dated 1861, April 21, the following account of the discovery and early observations of the same Comet:—

"I discovered this Comet on April 4, $11^h\ 12^m$, in the head of *Draco*, and fixed its place by the neighbouring stars; its approximate place was—

R.A. $17^h\ 40^m$ North Declination 57°

On April 10, $11^h\ 34^m\ 42^s$, its place was

R.A. $17^h\ 7^m\ 42^s{\cdot}76$ North Declination $59^\circ\ 30'\ 8''$

On April 14 (hour not given)

R.A. $16^h\ 36^m$ North Declination 63°

On April 20, 10^h

R.A. $15^h\ 40^m$ North Declination 68°

"Its brilliancy has remained nearly the same from April 9 to 20; on the 20th it appeared, with an aperture of $4\frac{1}{2}$ inches and power of 30, as bright as the cluster in the sword-handle of *Perseus*, or the nebula of *Cancer*, to the unassisted eye; and with a diameter of 3′."

No details are given as to the method of fixing the Comet's place on April 10, 14, or 20.

It appears by a letter from Mr. Parkin, dated St. John's Wood, Regent's Park, May 1st, that the Comet was seen by him on the night of April 29th at $11^h\ 45^m$; estimated right ascension $11^h\ 20^m$, declination 61° 30′; and on the night of May 1st, with the naked eye, the position then being right ascension $10^h\ 45^m$, declination 55° 20′.

Extract of a Letter from M. Le Verrier to Mr. Hind.

"I do not know if you have remarked in the *Astronomische Nachrichten* that Mr. Lehmann insists that 0·0000005 must be added to the radii-vectores of *Mercury* calculated from my Tables.

"It is a mistake; Mr. Lehmann has not understood that if the alteration he proposes were admitted it would be necessary to change in the same ratio the Earth's distance from the Sun, and thus nothing would be altered in the apparent positions of the bodies. The unit is arbitrary, and Mr. Lehmann does not appear to have a clear conception of that which is adopted in astronomical practice.

"If you think proper to communicate this note to the Royal Astronomical Society, I beg you to do so."

The Minor Planets (63) and (64) have been named *Ausonia* and *Angelina* respectively; the latter name refers to Zach's Astronomical Station at Notre Dame des Anges, near Marseilles. The name *Maximiliana* has been proposed for the Minor Planet (65).

The figures 1 and 3 in Mr. Birt's paper on the "Apparent Rotation of a Solar Spot," pp. 144 and 146, are incorrectly placed. Figure 1 should be turned round in its own plane through a right angle, so as to bring the right-hand side uppermost, and figure 3 should be turned round through two right angles.

It has been pointed out to the Editor that the numbers in Mr. Drach's auxiliary table for the calculation of the log. sin. and log. tan. of small arcs in the last number of the *Monthly Notices*, pp. 147–152, are to be found in Callet's Tables, and elsewhere. Also that a method of finding the latitude without a clock, by means of an altazimuth, similar to that alluded to by M. Radau, p. 168, is given by M. Littrow, *Memoirs*, t. ii., pp. 321–324 (1826).

MISCELLANEOUS INTELLIGENCE.

Mr. Lassell desires to intimate that in consequence of his going to Malta this summer with his large Equatoreal, his smaller telescopes are to be disposed of; and as *they must be taken down and removed* within the next two or three months, he wishes to dispose of them as early as he can.

The smaller of these is the 9-inch Equatoreal, described in the twelfth volume of the *Memoirs of the Royal Astronomical Society*. The larger is the 2-foot Equatoreal, in part described in the eighteenth volume of the above work, and is the telescope with which the former Maltese observations were made. Both these telescopes are in the most perfect and durable order and condition; and their optical performance is, he believes, sensibly perfect to the most fastidious eye; and excepting that the 9-inch has never had a clock-work driving-motion applied, all the conveniences which frequent use could suggest have been successively added.

Mr. Lassell will be glad to answer any inquiries respecting either or both telescopes which a purchaser may wish to make.

Bradstones, Sandfield Park, near Liverpool,
23d April, 1861.

RECENT PUBLICATIONS.

The twelfth volume of the *Smithsonian Contributions to Knowledge* contains an account by Lieut. Gilliss of the Total Eclipse of the Sun on Sept. 7th, 1858, as observed near Olmos in Peru, (see *Monthly Notices*, vol. xx. p. 298) and also the

Astronomical Observations in the Arctic Seas by the late Dr. Kane, made during the Second Grinnell Expedition in search of Sir John Franklin in 1853, 1854, and 1855, at Van Rensselaer Harbour and other points in the vicinity of the north-west coast of Greenland, reduced and discussed by Charles A. Schott. The observations determine the latitudes and longitudes of Van Rensselaer Harbour and various other stations, and appended to the paper is a map based on the astronomical results.

Handbuch der Kugelfunctionen. Von Dr. E. Heine, 8vo. Berlin, 1861.

The work is intended to be as well an introduction to as a systematic exposition of the theory of the class of functions commonly called Laplace's functions (but originating in Legendre's functions of a single variable) which play so important a part in the theories of attraction and the figure of the earth, and in other parts of mathematical physics. The author has consulted, and in part reproduced, the investigations of the last-named two geometers, and of Gauss, Jacobi, Lejeune-Dirichlet, Green, Neumann, Lamé, and others, and his treatise appears to be a most valuable monograph on this part of mathematics. It may be remarked that the term Kugel-function (sphere-function) employed by him after Gauss, is somewhat too restricted, as the researches of, in particular, Neumann and Lamé relate to ellipsoids of revolution and of three unequal axes. The latter part of the work comprises applications to the theory of mechanical quadratures (after Gauss) and to the theories of attraction and heat.

The Mathematical Works of Isaac Barrow, D.D. Edited for Trinity College by W. Whewell, D.D., Cambridge, 1860.

The principal contents of the volume are the Lectures which Barrow delivered as Lucasian Professor of Mathematics, an office which he held from 1664 to 1670. And these consist of three series,—the Lectiones Mathematicæ, the Lectiones Opticæ, and the Lectiones Geometricæ; the first being on the general principles of mathematics, the second containing propositions of optics proved geometrically, and the third, treating of properties of curve lines. The volume contains also the preface and dedication to Barrow's edition of Euclid, and the preface to his edition of the works of Archimedes, Apollonius, and Theodosius.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI. *May* 10, 1861. No. 7.

Dr. LEE, President, in the Chair.

E. D. Johnson, Esq., 9 Wilmington Square;
Rev. R. C. Lumsden, Sheffield;
Basil Woodd Smith, Esq., Hampstead; and
R. C. May, Esq., Great George Street, Westminster,
were balloted for and duly elected Fellows of the Society.

On the Light of the Sun, Moon, Jupiter, and Venus. By G. P. Bond, Director of the Observatory of Harvard College.

In a memoir recently communicated to the American Academy of Arts and Sciences I have given an account of experiments made at the Observatory, during the past year, upon the light of the Sun, Moon, *Jupiter*, and *Venus*. Attention was originally directed to the subject by the remarkable photographic intensity of the light of *Jupiter*, which was first noticed in March, 1851. This property has also been recognised by Mr. De La Rue, who has described his experiments in the *Monthly Notices* of the Royal Astronomical Society, vol. xviii. p. 55. I have found that the reflective capacity of the surface of *Jupiter* for the photographic rays is fourteen times greater than that of the Moon: in other words, out of

an equal quantity of light incident upon each of the two bodies *Jupiter* reflects fourteen times more of the chemical rays than the Moon does. Hence we have,

$$\frac{\text{Photographic albedo of Moon}}{\text{Photographic albedo of Jupiter}} = \frac{1}{14}.$$

I am satisfied that no considerable difference of colour, such as has been supposed by De La Rue, exists in the light of the two bodies — certainly none sufficient to account for their very unequal chemical action. From several trials made for the purpose, it would seem that the reflective capacity of the Moon's surface for the photographic rays is not inferior to that of the objects which give the prevailing tone of light to a landscape-view on the earth. On the other hand, no opaque substance has been found capable of reflecting light sufficient to act upon the plate with the same rapidity as *Jupiter*, when the illumination to which both objects are exposed is reduced to the same intensity.

The experiments, though liable to the uncertainty incident to all photometric measurements, are sufficient to prove an excess of photographic intensity in the light of the planet not susceptible of any ready explanation. They have suggested a series of comparisons of the optical intensity of the light of the bodies in question, which have led to the conclusion that the whiteness (*albedo*) of the surface of *Jupiter* exceeds that of any known opaque substance. Even the dusky belts give more light than an equal area of new-fallen snow would do if exposed to the same intensity of solar illumination. The fact is the more remarkable from the circumstance that occasionally white streaks and minute bright spots have been seen upon its disk much more brilliant than the general surface.

In a question where disturbing influences so easily mislead the judgment, it is desirable to bring together the results of different methods of examination. The following affords, perhaps, the most decisive confirmation of the fact of the superior brilliancy of *Jupiter*. I have found, from my own observations, the photometric proportion

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6430},$$

which is confirmed by the results of Sir J. F. W. Herschel's valuable collection of photometric comparisons made at the Cape of Good Hope, giving

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6620}.$$

This is derived, not from actual comparisons of *Jupiter* and the Moon, but indirectly from the ratio

$$\frac{\alpha \text{ Centauri}}{\text{Mean full Moon}} = \frac{1}{41400},$$

differing from Herschel's result published in his *Outlines of Astronomy*, principally on account of a change introduced into the corrections applied to the light of the several phases of the Moon to reduce them to the full phase, which will be more fully explained presently. For the relation between *α Centauri* and *α Lyræ*, we have

$$\text{Log.} \frac{\alpha \text{ Centauri}}{\alpha \text{ Lyræ}} = 0 \cdot 1200,$$

derived from determinations by Seidel and Herschel. Seidel* has obtained, from a very complete discussion of the subject, the values

$$\text{Log.} \frac{\text{Sun}}{\alpha \text{ Lyræ}} = 10 \cdot 4499 - \text{log. albedo Jupiter},$$

$$\text{Log.} \frac{\text{Jupiter at mean opposition}}{\alpha \text{ Lyræ}} = 0 \cdot 9158.$$

From the above numbers we obtain

$$\text{Albedo of Jupiter} = \frac{532000}{S}$$

where S is the ratio between the light of the Sun and of the mean full Moon. If, now, we substitute in this last result the value

$$S = 550000,$$

which is the mean between the determinations by Bouguer and Wollaston, we find

$$\text{Albedo of Jupiter} = 0 \cdot 967,$$

or more than double that attributed by Lambert to a surface of the finest white lead (cremnitz white), which gave the highest albedo, viz., 0·423, of any substance experimented upon by him.

* Untersuchungen über die Lichtstärke der Planeten *Venus*, *Mars*, *Jupiter* und *Saturn*. 4° Munich, 1859.

The values attributed to S by Bouguer and Wollaston, viz.,

$$S = 300{\cdot}000 \text{ by Bouguer,}$$
$$S = 810{\cdot}072 \text{ by Wollaston,}$$

are certainly very discordant, though not more so, perhaps, than the difficulties attending the subject would lead us to expect. A new determination, which I have made by a method differing from those employed by them, gives

$$S = 470{\cdot}980.$$

I have made use of the Bengola light as an intermediate standard of comparison, the colour of its light agreeing very closely with that of moonlight. The observations upon the intensity of moonlight give

$$\text{Albedo of Moon} = \frac{45{\cdot}193}{S}$$

$$\text{,,} \quad \text{,,} \quad = \frac{1}{12{\cdot}2} \text{ for } S = 550{\cdot}000,$$

$$\text{,,} \quad \text{,,} \quad = \frac{1}{10{\cdot}4} \text{ ,, } S = 470{\cdot}980,$$

for the relative albedos of the Moon and *Jupiter*.

$$\frac{\text{Albedo of Moon}}{\text{Albedo of Jupiter}} = \frac{1}{11{\cdot}47},$$

and, consequently, for *Jupiter* an albedo of very nearly unity, if we take $\frac{1}{11}$ as the albedo of the Moon. Thus all the data indicate a remarkable excess of brilliancy in the light of *Jupiter*.

For the relative albedos of *Venus* and *Jupiter*, I have found the proportion $\frac{1}{1{\cdot}10}$. Seidel gives $\frac{1}{1{\cdot}044}$ for the same ratio. I am inclined to think, however, that the albedo of *Venus* is, in both instances, estimated too high, since it depends mainly upon observations made near the epoch of greatest brilliancy, or between that point and the inferior conjunction, where the illuminated phase occupies but a small part of the disk. The line of incidence and reflection thus approaches the direction of a tangent to the surface; and, as a necessary consequence, the tendency to regular reflection in an opaque surface so presented will have the effect of increasing the quantity of light received from the crescent phases, especially as the planet approaches inferior conjunction.

It is not possible to estimate the amount of light regularly reflected; but there can be no doubt that Lambert's phase-formula, which has been employed in the reductions, will give, on this account, a sensibly higher albedo from observations at the narrow crescents than would be obtained from other phases.* Seidel's observations contain a confirmation of this inference.

In comparing the light of the Moon with the light emitted through a small aperture in a screen placed in front of the flame of a Carcel lamp, arranged with a view to secure a constant standard of illumination, I have obtained the following values of the logarithms of the quantity of light received from its various phases: v represents the angle of elongation of the Moon from the Sun, and H_0 the relative quantity of moon-light from the corresponding phase, taking the light of the mean full Moon as the unit.

$v =$ 0°	Log. H_0	$= -\infty$
20	,,	7·224
40	,,	8·049
60	,,	8·574
80	,,	8·974
100	,,	9·291
120	,,	9·551
140	,,	9·763
160	,,	9·931
180	,,	= 0·000

The observations have been freed from the effect of atmospheric extinction, and reduced to the mean distance of the Moon from the Earth and Sun.

Herschel's photometric observations made at the Cape of Good Hope upon the light of the Moon and of various fixed stars have furnished, after reduction, the following comparisons with value of log. H_0 taken from the above table —

	Log. H_0.	Cape Obs.	Diff.	Wt.
$v =$ 102°·2	9·324	9·368	−0·004	7
121·7	9·574	9·560	+0·014	8
131·3	9·681	9·711	+0·030	9
135·7	9·724	9·725	−0·001	9

* It is well known that *Venus* is visible in the day time to the naked eye, at near the time of its greatest brightness. I have often seen *Jupiter* with the naked eye while the sun was high above the horizon and shining clearly; and, on one occasion, *Sirius*. From the readiness with which the latter could be discerned, in a position where much of its light must have been lost by atmospheric extinction, I should think it possible to see α *Lyræ* also under favourable circumstances.

	Log. H_0.	Cape Obs.	Diff.	Wt.
$v = 143°.7$	9.805	9.778	+0.027	10
158.7	9.920	9.868	+0.052	13
167.0	9.964	9.991	−0.027	6
179.3	0.000	0.157	−0.157	2

With the exception of the last difference, depending upon an isolated observation made under unfavourable circumstances, there is a good agreement between the two series. The present reduction of the *Cape Observations* has been made without regard to Herschel's hypothesis respecting the impression made by the light of the stars upon the eye, as influenced by a change in the illumination of the background of the sky by varying amounts of moonlight, viz., that "the effective impression of a star on the retina is inversely as the square of the illumination of the ground of the sky on which it is seen projected." *

From the manner in which our values of log. H_0 have been obtained, they could not have been affected by this condition; and their accordance with the *Cape Observations*, uncorrected by the hypothesis, shows very clearly that the latter is not necessary to satisfy the observations. And yet it is remarkable that Herschel should have been able, by means of it, to represent completely a large series of observations otherwise wholly discordant. From a full investigation of the subject, the details of which are presented in the memoir, it appears that the true explanation of the discrepancies noticed by Herschel is to be found in the anomalous manner in which the Moon reflects light to the Earth from its different phases, in consequence of which the quantity of moonlight increases much more rapidly towards full-moon, compared with the phases on either side of it, than can be accounted for by the formulæ of Lambert or of Euler—so much so that, taking the full-moon as a standard, even Lambert's, which accords best with observation, makes the observed light at quadrature from two to three times fainter than is indicated by the theory.

Herschel's formula for the relative enfeeblement of the light of the stars, while it affords a very precise representation between quadratures and full-moon, if interpreted as a consequence of an actual variation of the amount of moonlight, is perfectly consistent with the results of my own investigation for the limits including the observations which have been discussed by him.

The following are the results of a comparison of the logarithms of the observed amounts of mean moonlight at different angles of elongation; *v*, the unit, being the amount from the

* *Results of Astronomical Observations made at the Cape of Good Hope*, p. 356.

mean full-moon for which $v_0 = 180°$, with the logarithms computed from the formulæ of Lambert and Euler, and from an empirical formula, in which the light is assumed to vary as $\sin^6 . \frac{1}{2} v$, which differs scarcely sensibly in its results from Herschel's formula under the above construction of its significance. It will be seen that the latter accords well with observation up to about $v = 90°$, and suddenly diverges from a correct representation between new and half-moon, phases which were not included among the *Cape Observations.*

	Obs'd. Moonlight. Log. H_0.	Lambert. Log. $\frac{\sin v - v \cos v}{\sin v_0 - v_0 \cos v_0}$	Euler and Herschel. Log. $\sin^2 \frac{1}{2} v$.	Log. $\sin^6 \frac{1}{2} v$.
$v =$ 0	$-\infty$	$-\infty$	$-\infty$	$-\infty$
20	7·224	7·653	8·479	5·438
40	8·049	8·536	9·068	7·204
60	8·574	9·037	9·398	8·194
80	8·974	9·374	9·616	8·848
100	9·291	9·613	9·768	9·305
120	9·551	9·785	9·875	9·625
140	9·769	9·903	9·946	9·838
160	9·931	9·975	9·987	9·960
180	0·000	0·000	0·000	0·000

On the Spiral Structure of the Great Nebula of Orion. By G. P. Bond, Esq., Director of the Observatory of Harvard College.

A disposition in the light of this nebula to radiate outwards and in a southerly direction from the neighbourhood of the *trapezium*, is noticed in my father's memoir, published in 1848, in which are named, as particular localities, Herschel's subnebulous region and the preceding side of the *Regio Huygeniana*. This peculiarity has since attracted attention on many occasions; but it is only recently that it has been subjected to a minute and systematic examination, the results of which I propose now to communicate.

In the season of 1857–58 I undertook the formation of a catalogue of the stars comprised within a square of 40′ having *θ Orionis* as its centre. One hundred and twenty-one of the brighter stars were selected, and their positions determined, to serve as points of reference for filling in the remainder, which were mostly too faint for observation under a strong illumination of the micrometer wires. This was completed in 1858. The order of magnitude of the stars was subsequently made

the subject of careful study by the method of sequences described by Sir John Herschel in the "Results of Astronomical Observations made at the Cape of Good Hope." The whole number of stars included up to the end of the season, 1857–58, was two hundred and sixty-two; but it must be remembered that innumerable fainter stars have been omitted, on account of the difficulty of observation, and many of them appearing only on occasions of the finest definition.

In the following year, 1858–59, the area above indicated was divided into four charts, on which the outlines of the nebulosity were traced in chalk and white water-colour, laid on a dark ground. These were next combined in a single drawing, which was subsequently compared with the nebula, and corrected. The particular feature, which it is now proposed to describe, did not, however, present itself in its full force until the present year. During the months of December, January, February, and March last, favourable opportunities were taken to review the whole region, with particular reference to the arrangement of the nebulosity in long wisps, alternating with darker spaces sweeping outwards from the vicinity of the *trapezium*. A careful scrutiny of the intermediate dark channels was of considerable assistance in tracing the fainter convolutions.

The form and dispositions of the whirls were thus defined by two independent processes, the nebula being first sketched as a bright object on a dark ground, and again, its darker openings and channels as dark objects on a bright ground.

The quarter designated in Herschel's chart* as the *Regio Godiniana* was first explored. The nebulosity was here resolved into an assemblage of three or four long wisps, interlaced with each other, or crossed by off-sets, which were ultimately traced from a point near the northern margin of the *Sinus Magnus*, over the whole length of the *Regio Picardiana* and the *Regio Godiniana*, forming a sweep of 120°. After passing the well-defined northern boundary of the last-named region, and beyond Herschel's stars *o* and ξ, these wreaths bend rather suddenly, and tend towards the south preceding direction. Indications of their presence in this quarter are imperfectly suggested in Lassell's and in Sir J. Herschel's latest drawing. From this point feeble traces exist for 10′ or 15′ in a south preceding direction. Their course over the *R. Picardiana* gives a decidedly reticulated aspect to the whole region; but, though bright, they are here so closely intertwined and connected by off-sets, that it is a matter of no little difficulty to gain a clear comprehension of their proper relations. The complexity of the details is further increased by several off-shoots from this quarter, which cross over into the adjacent *R. Derhamiana*; still the general effect is easily recognised.

* *Mem. Ast. Soc.* vol. ii.

From the southern corner of the *Regio Picardiana*, and from those parts of *R. Derhamiana* and *R. Huygeniana*, which lie near the *trapezium*, on its north preceding and preceding sides, a number of narrow and bright branches diverge, their extremities tending also to the south preceding direction. Some of these cross the *R. Gentiliana*, and seem to merge together, forming a nebulous mass, which can be followed through an arc of 10′ or 15′. Others, which are less curved, originate near the *Sinus Gentilii;* these are narrow and somewhat tortuous.

It is to be noticed that the initial direction of the wreaths (*Nebelstreifen*) changes continuously from an angle of position of 330°, on the northern margin of the *Sinus Magnus*, to one of 220°, or less, at the *S. Gentilii*, and the sweep of the curve correspondingly diminishes, so that throughout the whole nebulous region preceding the sharply-defined apex of the *R. Huygeniana*, the extremities of the filaments have a pretty uniform tendency in the angle of position, 220°. As soon, however, as we pass to the fields on the following side of the apex, a change is immediately apparent; the ultimate direction being about in the angle 160°. The principal group of wisps results from the resolution of the *R. Messeniana*, and the region between the *trapezium* and the *Proboscis Minor*, including both these features, into four or five distinct wreaths, having a common initial direction in the angle of position 110°. The very bright nebulosity lying between the *S. Gentilii*, the *trapezium*, and the *R. Subnebulosa*, cannot be resolved into a regular structure, but three or four condensed spots, constituting the most brilliant part of the nebula, close on the south preceding side of the *trapezium*, are plainly distinguished as tufts or curled off-sets from a prominent wisp of light, which extends from its origin near the *trapezium* across the *R. Gentiliana*.

The general aspect of the greater part of the nebula is, therefore, that of an assemblage of curved wisps of luminous matter, which, branching outward from a common origin in the bright masses in the vicinity of the *trapezium*, sweep towards a southerly direction, on either side of an axis, passing through the apex of the *Regio Huygeniana*, nearly in the angle of position 180°. About twenty of these convolutions have been distinctly traced, while others, giving a like impression, are too faint or too intricate to be subjected to precise description. It may, in fact, be properly classed among the "spiral nebulæ," under the definition given by their first discoverer, Lord Rosse; including in the term all objects in which a curvilinear arrangement, not consisting of regular re-entering curves, may be detected.

That the existence of this feature in the great nebula of *Orion* should have hitherto escaped notice, after the many careful scrutinies to which it has been subjected with the help of the largest instruments and the most skilful observers, may

seem scarcely credible. A few words of explanation on this point will not, therefore, be amiss. It is to be ascribed partly to the confusing effect produced by the crossing and intersection of the principal striæ and of their off-sets, which the eye cannot unravel without the aid of some clue to their mutual relation and significance, and partly also to the faintness of some of the details, which are, nevertheless, very essential features in a correct apprehension of its structure, supplying, as they do, what would otherwise appear as breaks of continuity, and assisting materially in the recognition of a principle of regularity pervading the whole structure. Until the law of relation and continuity in the several parts of such an object is entertained in the mind, it must remain an incoherent, confused assemblage of material, having no orderly or connected arrangement.

The change from the previous notion of its configuration is not more considerable than that which took place with reference to the celebrated nebula 51 *Messier*, in which the original discovery of the spiral arrangement was made. This object had been subjected to a careful examination and description by both the Herschels; but neither their drawings nor descriptions furnished the slightest intimation of a spiral structure. It deserves particular notice, too, that there was no want of sufficient optical power to exhibit the appearance in question; for the spirality is seen with perfect distinctness in a refractor of 15 inches aperture, and must certainly be within reach of the 20-foot Herschelian reflectors. Nor can it for a moment be thought that the earlier observations and delineations were in any proper sense erroneous. They were simply made at a great disadvantage in the absence of a clear conception of the general plan of structure presented in the object. Some of the details indispensable to its recognition, being only faintly presented, were overlooked, or, appearing by mere suggestions and glimpses of vision, they conveyed an erroneous impression: in this way the mutual relation of the various parts came to be entirely misconceived. The missing links were supplied by the larger optical power of Lord Rosse's telescope, too plainly not to insure notice; and the nebula then presented itself under a totally different aspect. Instances of similar revelations, completely at variance with previous conjectures, have indeed so often occurred in the history of astronomical discovery, that the process ought to be regarded as the ordinary rule rather than as an unusual exception.

There are several other features of minor importance which have engaged attention in the course of this survey of the nebula. One of these is the large number of instances in which collections of nebulous matter are found associated with stars, frequently in the form of little wisps, shooting off in a southerly or south preceding direction. Another is the predominance of small stars in the nebulous regions. Two

remarkable instances occur where there is a deficiency of nebulous matter in close proximity to bright stars, which are yet closely encircled by it. These are the bright groups of the *trapezium*, the central comparative darkness of which has been noticed by many observers, and ι *Orionis*. Lord Rosse's figure of the latter is decisive in this point. These features seem to favour the idea of a physical association of the stars with the nebula. The existence of a spiral arrangement of its component parts falls in with the suggestion of a stellar constitution, since, among the objects exhibiting this peculiarity, are included, not only resolvable nebulæ, but actual star-clusters, such, for instance, as the great cluster in *Hercules*, which has an unquestionable curvilinear sweep in the disposition of its exterior stars.

On the Morning Illumination of the Western Portion of the Mare Humorum. By W. R. Birt, Esq.

In the communication which I had the honour of submitting to the Society at its last meeting, I solicited attention to the appearance of those craters that, standing near the borders of the *Mare Humorum*, had had those portions of their walls broken down that faced the *Mare*. As an admirable opportunity occurred on the evening of April 20th, 1861, of noticing the morning illumination of the western portion of the surface of the *Mare*, which presented some features, perhaps interestingly connected with those that have already claimed attention, some of which appear to be but obscurely indicated in Beer and Mädler's map, I have considered it important to submit to the Society my observations of them as a further contribution to the selenography of this part of the Moon's surface.

At $7^h\ 15^m$ G.M.T., April 20, 1861, the terminator crossed the *Mare*, extending from the western flank of *Gassendi* to the western wall of *Vitello*, the interior of the eastern wall of which was very brilliant, its floor as well as the included mountain being in perfect darkness.

The western flank of *Gassendi* appeared to be very rugged, a portion only of the summit of the south-west wall was seen projecting into the night side of the Moon; this illuminated portion terminated abruptly, the last peak being detached. To this detached peak, which Beer and Mädler mark θ, I beg to solicit attention presently.

On the surface of the *Mare* between the line across it, joining the two ringed mountains above named, and its western borders, including the arm on which *Hippalus* stands, occur

some interesting *curved* ridges, the convexities of the curves being directed invariably towards the border of the *Mare*, as if they had resulted from the operation of a force that had so acted as to elevate them in some degree *parallel* with the border, *the least parallelism occurring towards the centre of the Mare.* These ridges are true elevations above the surface, casting well-defined shadows. In describing them for the sake of easy reference, I append to each a Roman numeral.

I. This ridge is at this epoch of illumination nearest the terminator; it takes its rise at its southern extremity from the point of intersection between the eastern wall of the ring of *Vitello* and the western of the large disrupted crater, mentioned in my last communication, and runs with a slight divergence from parallelism with the terminator, for about one-fifth of the breadth of the *Mare, i. e.* from *Vitello* to *Gassendi.* At this point, marked δ by Beer and Mädler, it abruptly changes its direction, running here towards the north-west, casting a considerable shadow; and, from a later period of the observations, this part would appear to be the western ring of a nearly *obliterated* crater greatly ruined. The ridge terminates *in a point against* a small crater marked D in Beer and Mädler's map. *The crater is perfectly detached from this point, and appears to have been elevated on the southern extremity of a ridge, forming a continuation of the foregoing,* and extending about half-way across the *Mare.* The crater is more elevated than the ridge, and casts a well-defined shadow. I have italicised the position of the crater D, as Beer and Mädler's map exhibits a *continuous* ridge.

II. and III. Westward of I. two ridges take their rise respectively from two mountains north of *Vitello,* marked by Beer and Mädler as two craters E and F, the eastern F being very near the ridge I, and the western E north-west of *Vitello,* and north-east of a small crater on the surface of the *Mare,* just within its south-west mountainous boundary, not given by Beer and Mädler, unless the crater E be it; in which case we have no mountain on the map. These two ridges, the rise of which from the mountains or craters are not given by Beer and Mädler, *converge,* and with more or less sinuosity skirt the ridge I, both receding considerably from it in the neighbourhood of the crater D, well shown by Beer and Mädler, with one between, which was not apparent to me on the evening of the 20th. In this part of their course they form considerable *bends* around the crater D, both apices of the bends being in a line with the crater.* A little to the north

* On consulting Beer and Mädler's map, I find the crater D, the apices of the bends of the ridges, and the partially destroyed crater *Hippalus, in the same line.* I shall look, should I have the opportunity on a future occasion, with great interest for an ocular confirmation of this. 1861, May 20, 11 to 12 hours; *Hippalus* is in the same line with the bends and crater D, but not that portion of the wall that appears to have been destroyed.

of these bends, the ridges II. and III. unite, and proceed to a point nearly midway between two small craters that appear to have been elevated at a period posterior to that of the formation of the surface of the *Mare*. Beer and Mädler mark the eastern crater 1, and bring the whole of the united ridges to it. This I failed to see.

Beer and Mädler depict the ridges in this part of the *Mare* as being more numerous than I was able to ascertain. My observations were made without reference to the map. I did not consult it until some days afterwards.

IV. From the westernmost of the two craters just alluded to, a slightly undulating ridge extends to the southern wall of *Gassendi*, and passes into the night side of the Moon as a fine delicate line of light.

As the illumination of the southern wall of *Gassendi* proceeded, the separate peak θ of Beer and Mädler, mentioned above, was seen to occupy a position *slightly within* the general boundary of this portion of the ring of the crater, *as if it had been pushed inwards towards the crater*. This is well depicted by Beer and Mädler. It is at this point that the ridge IV. terminates, apparently resting as a buttress against the dislodged part of the ring, also well shown by Beer and Mädler; the remaining portion of the southern wall of *Gassendi* towards the east attains a much lower altitude, as, during the continuance of the observations, four hours, every part remained in darkness.*

V. and VI. Two somewhat lower ridges extend from the bend of III. to the crater from which IV. takes its rise; one only of these depicted by Beer and Mädler.

The above-described ridges, which were all I was able to see with my instrumental means, are situated on the western part of the *Mare Humorum;* they can hardly, if at all, be regarded as ranges of mountains, but may, I apprehend, be considered as ranges of *low* hills, the wall of the nearly obliterated crater rising to the greatest height. The curve of this wall is not well shown by Beer and Mädler.

Epoch, 1861, April $20^{d}{\cdot}37$; Moon's age, $10{\cdot}57$. Greatest libration, S.E. $+\ 2^{d}{\cdot}64$; epoch, April $17^{d}\ 17^{h}\ 19^{m}$. Perigee, $-\ 3^{d}{\cdot}58$: epoch, April $23^{d}\ 23^{h}$.

* From my observations of May 20, 11 to 12 hours, it would appear that the southern part of the ring is scarcely, if at all, elevated above the surface of the *Mare*.

Phenomena of Jupiter's Satellites observed with the Telescope of the Heliometer, at the Radcliffe Observatory, Oxford. By the Rev. R. Main.

1861, April 17. While engaged in attempting to complete the adjustment of the half-object-glasses of the heliometer, by means of the image of *Jupiter*, I observed that the 1st and 2d Satellites were approaching each other; and it appeared to me that they would pass very nearly, if not exactly, over each other. I, therefore, continued to watch them till the conjunction took place, and was not disappointed, as they came into actual contact, and covered each other so completely, that only one single object with perfect sphericity was visible.

I first used a power of 150, and when they came very near each other, I put on a power of 200; but with neither was the definition very good, on account of the east wind. I had previously made these images, formed by the halves of the object-glass, cover each other at the zero very satisfactorily.

The following is the observation of time of contact:—

The conjunction appeared to be perfect—that is, I could perceive no defect of sphericity at $12^h\ 30^m\ 30^s$ clock time (sidereal.)

I could discern no change up to $12^h\ 38^m$, when I began to perceive that the image was elongating.

At $12^h\ 39^m\ 45^s$, I could perceive that the satellites were separating, though the surfaces were still in contact.

At $12^h\ 41^m\ 45^s$, they had separated by a space equal to the diameter of either, the diameters appearing to be very nearly equal.

Satellite I. was approaching *Jupiter*, and Satellite II. was receding from him on the (apparently) west side.

The clock time was 50^s slow of sidereal time.

1861, April 23. *Eclipse (reappearance) of Jupiter's 3d Satellite.*

The satellite was seen, very faint, at $13^h\ 19^m\ 15^s$ clock time, and took several seconds to acquire its full brightness. The observation very good.

The clock was slow of sidereal time $1^m\ 3^s{\cdot}8$.

Hence Oxford sidereal time of reappearance was $13^h\ 20^m\ 18^s{\cdot}8$, and the mean solar time was $11^h\ 12^m\ 25^s{\cdot}1$.

The Greenwich mean time given in the *Nautical Almanac* is $11^h\ 15^m\ 18^s{\cdot}3$.

April 24. *Eclipse (reappearance) of Jupiter's 2d Satellite.*

The satellite was first seen, exceedingly faint, at $12^h\ 25^m\ 13^s$ clock time, and it did not reach its full brightness for more than a minute.

The clock was slow $1^m\ 5^s{\cdot}0$.

Hence Oxford sidereal time of reappearance was $11^h\ 26^m\ 18^s{\cdot}0$, and the mean solar time was $10^h\ 14^m\ 37^s{\cdot}2$.

The Greenwich mean time given in the *Nautical Almanac* is $10^h\ 20^m\ 18^s{\cdot}9$.

May 6. *Eclipse (reappearance) of Jupiter's 1st Satellite.*

The satellite was seen as a very minute point, not brighter than the 12th magnitude, at $12^h\ 10^m\ 41^s$ clock time; and I watched it till it seemed to have acquired its full brightness, which was not till $12^h\ 12^m\ 30^s$ (though clouds which partially veiled it after the reappearance for a few seconds at a time may have interfered with my judgment).

The clock was $1^m\ 14^s$ slow.

Hence Oxford sidereal time of reappearance was $12^h\ 13^m\ 44^s$, and the mean solar time was $9^h\ 14^m\ 54^s{\cdot}3$.

The Greenwich mean time given in the *Nautical Almanac* is $9^h\ 18^m\ 20^s{\cdot}9$.

A communication was received from Mr. Thomas Barneby, giving an account of the appearance of *Jupiter* and his satellites, as observed on the night of the 5th April, 1861. The shadow of the third satellite was at first seen in the shape of a broad dark streak, such as the cone of the shadow would represent in a slanting direction; but it shortly afterwards appeared as a circular spot, perfectly dark, and much larger than the shadow (which was visible at the same time) of the third satellite. The phenomena were illustrated by a sketch.

Results of Meridional Observations of Small Planets; and of the Observations of Phenomena; made at the Royal Observatory, Greenwich, during the month of April, 1861.

(Communicated by the Astronomer Royal.)

Iris (7).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 16	13 56 8·0	15 36 51·95	113 45 15·68
24	13 18 25·5	15 30 35·66	113 20 38·50

Hebe (6).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 4	9 58 48·6	10 51 34·90	70 48 44·13
5	9 54 22·9	10 51 5·02	70 44 56·99
8	9 41 13·0	10 49 42·62	70 35 39·15
11	9 28 15·2	10 48 32·40	70 28 8·38
16	9 7 8·0	10 47 4·43	70 19 50·36
20	8 50 40·0	10 46 19·76	70 16 48·79
23	8 38 34·8	10 46 2·48	70 16 27·96
24	8 34 34·5	10 45 58·09	70 16 41·50

Parthenope (11).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 4	10 20 33·6	11 13 23·50	79 1 13·75
5	10 15 59·9	11 12 45·57	78 57 20·20
16	9 27 14·5	11 7 14·27	78 28 8·32
20	9 10 14·4	11 5 57·63	78 23 8·99
23	8 57 45·1	11 5 15·93	78 21 28·30
24	8 53 38·6	11 5 5·31	78 21 11·64

Melpomene (18).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 4	7 39 22·7	8 31 46·12	71 46 52·15

Leda (88).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 8	10 46 24·4	11 55 4·79	100 55 37·03

Lætitia (89).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 10	11 42 34·1	12 59 16·75	86 6 29·78
16	11 14 37·4	12 54 54·80	85 29 21·28

Eugenia ㊺.

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, April 5	11 39 36·0	12 36 35·39	86 0 32·30
25	10 7 56·5	12 23 31·91	84 18 37·54
27	9 59 8·6	12 22 35·74	84 12 32·81

All the observations of N.P.D. are corrected for refraction and parallax.

The observations of *Angelina* ㊹, printed in the *Monthly Notice* for April, were made, 1861, March 21 and 22, and not, as there stated, March 15 and 22.

No occultations of Stars by the Moon were observed.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1861.			h m s	
April 5	IV.	Ingress, first cont.	11 7 58·4	J. C.
5	IV.	,, bisection	11 12 27·7	J. C.
5	IV.	,, last cont.	11 17 56·8	J. C.
5	IV.	,, first cont.	11 8 50·7	N.
5	IV.	,, bisection	11 12 35·1	N.
5	IV.	,, last cont.	11 16 34·4	N.
8	II.	Egress, last cont.	7 47 6·6	A. D.
16	III.	Ecl. reappearance	7 17 45·2	C.
23	III.	Ecl. reappearance (*a*)	11 16 39·0	E.

(*a*) The satellite was thought to have reappeared a few seconds before it was seen.

The initials E., C., J. C., A. D., and N., are those of Messrs. Ellis, Criswick, Carpenter, Davis, and Newcomb.

Mr. Carrington's Chronograph.

Mr. Carrington exhibited at the evening Meeting an instrument for the registration of time-signals on a fillet of paper, the parts of which were put in motion that their performance might be inspected in working order. He commenced his explanation by acknowledging the assistance he had received in carrying out his ideas from Mr. C. V. Walker, Telegraph Engineer to the South Eastern Railway Company, who permitted the works to be executed at Tunbridge by the skilled workmen at the clock-factory under his direction.

B

In devising a modified form of Chronograph his object was twofold; 1st, to supply a want felt last summer at Redhill during a period of great solar activity, of the power of recording many more signals in a given time than could be done by the ear, eye, and pencil; 2d, to endeavour to reduce the cost of such an instrument so considerably as to place it within the reach of all observers; for in his intercourse with private astronomers he had frequently become aware of the difficulty found by them in making observations of position where it was required to count and register differences of time with a half-second chronometer.

The parts of the instrument, of which full-size plans will be deposited with the Society, were mainly three; 1st, the reel carrying the fillet; 2dly, the machine for driving and stamping; and 3dly, a sustained pendulum, by which at every vibration a current was allowed to pass from a battery of three cells, and the time-pen of (2) made to register a time scale dot. The reel can require no particular description, but it may be stated that the fillet wound on it was in size and quality similar to that used for the London District Telegraphs, and may readily be procured at an extremely low price in any length and quantity. The pendulum was of a length beating $\frac{6}{10}$ seconds, (in the instrument exhibited) and was accompanied by only so much of the usual clock-train as was necessary for keeping up its vibrations and enabling it to do the work required, of making slight metallic contacts. For this purpose it was crooked at about one-fourth of its length from the point of suspension, and a steel point introduced directed upwards, which at every vibration in passing the lowest point touched a point on the other side of a small doubly inclined plane, placed beneath a horizontal flexible spring. By the momentary contact so made, the duration and delicacy of which was regulable by a screw, two ends of a wire were placed in metallic contact, and a current allowed to pass to the machine (2).

This portion (2) consisted of a train of wheels for driving and regulating the rotation of a narrow drum, over which passed the fillet, which was drawn along at a rate liable to very small variation from under an inking desk, through the bottom of which worked three small platina plungers or wire pens, dropped by the passage of galvanic currents through corresponding pairs of electro-magnets. The regulation of the rate of the driving train was effected by two small centrifugal spring pieces, attached to the circumference of a fly forming the last wheel of the train, and the friction of which against two opposed surfaces admitting of adjustment established and maintained an evenness of rate amply sufficient for the object in view. The arrangement of the inking apparatus is due to Prof. Wheatstone, from whom was borrowed the ingenious *idea of drilling* holes through the bottom of a metallic disk too

small to admit of the escape of a drop, and through which the plungers or pens descend freely, with their tips constantly moistened by the capillary action of the small holes in which they remain while at rest.

The descent of the middle pen was regulated by the pendulum, and recorded on the fillet a series of centre dots at distances indicating on the scale intervals of time of six-tenths of a second. The other two, which may be termed the A and B pens, are under the control of the observer, who holds in his hand a contact maker, with which either one or the other pen is made to descend instantaneously and record a dot. In Mr. Carrington's method of observing the positions of solar spots, the interval of passage of the Sun's diameter would be represented on the fillet by a length of about 10½ feet, divided into equal intervals, and on one side by the A pen would be recorded the contacts of limbs and spots with pen A, and on the other those of pen B, the unit of measurement employed being of no moment whatever; and it is evident that, wherever two coordinates can be observed instantaneously by this or analogous methods, the new Chronograph will be found an aid to the observer. Its especial use is, however, in cases where it is necessary to record with great rapidity, or in the absence of all light, as when a faint object is present in an equatoreal; other previously devised instruments being more suitable for meridional observation.

The machinery and weights of the instrument exhibited cost less than 12*l.*, a part of which was incurred by alterations necessary in a first trial, and with table, battery, and appurtenances, the whole did not exceed 13*l.* The essential parts of the common clock may be purchased in Clerkenwell at prices far less than would commonly be believed till known; and if a clever workman disposed to employ his evenings after usual hours can be met with, experiments similar to those from which resulted the above machine may be tried without very alarming or deterring expense.

Observations and Elements of Comet I., 1861.

(*Extract of a Letter from Mr. Bond to Mr. Carrington.*)

The comet discovered by Mr. A. E. Thatcher, of New York, on April 4th, has been observed here as follows:—

Comet I, 1861.

1861.	Camb. M.S.T. h m s	R.A. h m s	Decl. ° ′ ″
April 10	11 34 42	17 7 42·60	+59 28 12·8
11	9 27 6	17 2 26·69	60 9 0·2
14	9 1 27	16 40 14·35	62 30 7·1
18	14 21 33	15 49 15·55	65 52 42·9

On account of an error in the place of the comparison-star, the declination of the comet, April 9th, was erroneously reported to the *Astronomische Nachrichten*, and to the Bulletins of the Paris Observatory, as

$$+59^\circ\ 30'\ 13''\cdot8$$

instead of

$$+59\ 28\ 12\cdot8$$

Mr. Safford has computed the following elements of the Comet:—

T 1861, June 4·004, Washington M.T.

Motion direct.

	° ′
$\pi - \Omega = \omega$	213 15·30
Ω	29 15·13
i	81 14 23

Log q...... 9·96544.

Harvard Observatory, April 8, 1860.

Observations of the same Comet. By Sandford Gorton, Esq.

Mr. Gaunt and I observed the Comet at this place on the 4th of May, at 11 P.M. It was visible to the naked eye, appearing like an indistinct star of the 2d or 3d magnitude. It was sufficiently bright to be well seen in the field under an illumination which extinguished stars apparently of the 6th magnitude. In the dark field a tail was readily to be traced, extending in the S. F. quadrant to a distance of about a degree, as far as I could judge. Its rate of progress in declination was so rapid that we watched it approach and pass a star during the hour we were observing.

On the 6th and 8th I again saw it, but with difficulty, owing to the mist.

Last night (the 9th) was also misty, and the comet could scarcely be seen without the telescope.

The following are the approximate positions shown by my

Equatoreal, which, of course, are open to correction by more powerful instruments:—

	G.M.T.	R.A.	Decl.
	h m	h m s	° ′
May 4	11 0	9 51 10	+45 5
6	12 30	9 27 55	37 10
9	9 35	9 3 35	26 18
„	11 28	9 3 10	25 59½

Telescope, 4 feet focal length; aperture, 3⅜.

Observatory, Downs Road, Clapton,
May 10, 1861.

Discovery of Minor Planets (66), (67), (68) *and* (69).

The discoveries of the first three are announced in the *Astronomische Nachrichten*, No. 1308, and Circular of 6 May, 1861, and that of the last in Le Verrier's *Bulletin* of the 13th May, which contains also some later observations of (67) and (68).

Minor Planet (66). Discovered by Mr. H. P. Tuttle at the Observatory of Harvard College, Cambridge, U.S., on the morning of April 10th; magnitude 13. The following positions were obtained from comparisons made by Mr. Bond with a star of the 7–8 mag. W. 1011, occurring also in Santini's Catalogue and the Harvard zones 6 and 7, No. 76.

1861, April 9, $14^h\ 36^m\ 23^s$ Camb. M.T.

R.A.	Par. × Δ.	Decl.	Par. × Δ.
$11^h\ 59^m\ 45^s{\cdot}83$	$+0^s{\cdot}358$	$+0°\ 9'\ 12''{\cdot}7$	$+5''{\cdot}74$
	Daily Motion -43^s	$0'$.	

Minor Planet (67), *Leto*. Discovered by Dr. Luther at the Bilk Observatory, at 12½ on the night of the 29th of April, in R.A. $14^h\ 9^m\ 35^s$, Decl. $-11°\ 6'\ 3''$; magnitude 11. The following observation was made,—

	Bilk M.T.	R.A.	Decl.	Comps.
1861, April 29	$13^h\ 21^m\ 2^s{\cdot}0$	$14^h\ 9^m\ 32^s{\cdot}73$	$-11°\ 6'\ 15''{\cdot}1$	8
	Daily Motion	-54^s	$+2'{\cdot}2$	

The star of comparison being taken from Rumker's Catalogue:

	Mag.	App. Position.		Mean Position, 1861.	
April 29	6	$214°\ 0'\ 6''{\cdot}1$	$-11°\ 4'\ 53''{\cdot}0$	$213°\ 59'\ 16''{\cdot}6$	$-11°\ 4'\ 34''{\cdot}2$

The name was selected by Prof. Argelander, Dr. Krüger, and M. Tiele, at Bonn.

The following later observations by the discoverer are given in Le Verrier's *Bulletin:*—

	Bilk M.T. h m s	R.A. h m s	Decl. ° ′ ″	
April 30	10 52 17·5	14 8 44·76	−11 4 5·2	8 comp.
May 7	10 42 19·7	14 2 35·91	−10 48 1·4	10 comp.

Minor Planet (68). Discovered by M. Schiaparelli at the Royal Observatory of Milan, April 29; magnitude 11.

1861.	Milan M.T. h m s	App. R.A. h m s	App. Decl. ° ′ ″
April 29	11 26 5	10 22 13·83	+7 37 49·9
30	9 16 27	10 22 36·74	+7 38 47·2
May 1	8 53 56	10 23 3·19	+7 39 49·8
2	8 56 36	10 23 30·72	+7 40 36·9
3	9 1 30	10 24 0·02	+7 41 20·7
7	9 3 7	10 26 6·91	+7 42 36·2
8	9 5 56	10 26 41·46	+7 42 36·1
9	8 57 1	10 27 16·66	+7 42 23·4

where the observations on and after the 2d of May are taken from Le Verrier's *Bulletin.*

The planet at the time of its discovery was distant only 9′ from *Ausonia* (63), and it was at first taken for that planet.

Minor Planet (69), *Panopea.* Discovered by M. Goldschmidt at Fontenay aux Roses, near Paris, on the 5th of May, mag. 10–11. The following observations have been obtained:

1861.	Paris M.T. h m	R.A. h m s	Decl. ° ′ ″	
May 5	10	14 43 43	−14 20	(*a*)
10	10 44	14 38 30	−14 21 54	(*a*)
11	11 45	14 37 25	−14 23	(*a*)
14	10 10	14 34 16·91	„	(*a*)
14	10 45	14 34 15·30	−14 25 36	(*b*)
15	10 57	14 33 14·55	„	(*b*)
15	11 29	„	−14 26 19	(*b*)
16	9 55	14 32 14·8	−14 29 29	

		h m s	° ′ ″
(*a*).	Star of Comparison (1800) Berlin Cat.	R.A. 14 34 52	Dec. −14 8 3
	Reduced for 10 May	App. R.A. 14 38 15	Dec. −14 24 26
(*b*).	Star of Comparison (1800) Berlin Cat.	R.A. 14 29 56	Dec. −14 27 2
	Reduced for 14 May	App. R.A. 14 33 19·15	Dec. −14 43 36

The observations of the 14th, 15th, and 16th of May are taken from a letter dated $\frac{16}{17}$ May, 1861, to Mr. Carrington. The name *Panopea* was selected by Mr. Main.

Since the above was in type, the following communication has been received from Mr. Pogson:—

Discovery of a New Planet, "Asia."

This planet was found, like each of my previous ones, by means of my own manuscript charts; not by mere gleaning in the celestial fields prepared by other astronomers; a circumstance which enables me to assume with reasonable probability that I shall not have been preceded elsewhere. As it is the first discovery yet made in this quarter of the world, I have selected the name "*Asia,*" who, as one of the Oceanides, has, I conceive, as good a right to a place in the heavens as *Europa*, *Doris*, or several others of her sisterhood. The planet is between the 11th and 12th magnitudes.

The following observations have been taken by the Boguslawski method, using only one thick bar and two comparison stars, there being no dark field micrometer attached to the telescope. I believe them to be fully equal to any I could have made of so faint an object, had the most refined instrumental means been at hand.

1861.	Madras M.T.	App. R.A.	App. N.P.D.	Log. of Par. × Δ. R.A.	Log. of Par. × Δ. N.P.D.	Comp. Stars.
		h m s	h m s			
April 17	12 53 40	15 51 14·76	...	−9·265	...	*bc*
17	14 7 37	15 51 13·56	106 6 22·9	+6·704	−0·620	*bc*
18	11 50 39	15 50 50·72	106 1 12·7	−9·501	−0·578	*bc*
19	13 49 27	15 50 20·72	105 55 7·0	−8·368	−0·617	*bc*
20	11 46 44	15 49 53·93	105 49 50·1	−9·686	−0·579	*bc*
20	13 20 12	15 49 51·84	105 49 26·6	−8·934	−0·614	*bc*
21	11 59 5	15 49 22·97	105 43 55·3	−9·431	−0·587	*ab*

The second observation, on April 20, was taken and reduced by my fourth native assistant, Raganootha Chary, who readily comprehends and most willingly executes whatever I may recommend to his notice.

The adopted mean places of the comparison stars were these:—

		Mean R.A. 1861.	Mean N.P.D. 1861.
		h m s	° ′ ″
a	A.Z. 297·58 = 28997 Lalande	15 49 13·23	105 37 30·4
b	A.Z. 205·62	15 51 20·78	105 49 11·5
c	2026 Mädler's Bradley	15 52 31·93	106 7 14·7

The right ascension of 28997, being 6 seconds of time too great, was rejected, and Argelander's alone employed.

Madras Observatory, April 27, 1861.

The announcement, in the last Annual Report of the Council, of the death of Sir W. Dennison (p. 98), was erroneous. The Astronomer Royal has received a letter from him, dated April 8, then alive and well, and governing at Madras.

ERRATA.

Page 173, line 5 from top, *for* Lieut. Cuspendale, *read* Lieut. Carpendale.
— 178, — 20 — *for* L. H. Casella, *read* L. P. Casella.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI. *June* 14, 1861. No. 8.

Dr. LEE, President, in the Chair.

Wm. J. Rideout, Esq., Standish, near Wigan;
S. H. Winter, Esq., Trueby House, Woodford;
J. G. Perry, Esq., F.R.C.S.;
Wm. Penn, Esq., Stone, near Aylesbury; and
J. H. Dallmeyer, Esq., 19 Bloomsbury Street,

were balloted for and duly elected Fellows of the Society.

On the Secular Acceleration of the Moon's Mean Motion.

By W. F. Donkin, Esq., M.A., F.R.S., F.R.A.S., Savilian Professor of Astronomy in the University of Oxford.

The controversy respecting the Moon's acceleration is one upon which no mathematician, professionally connected with Astronomy, could be content to accept without examination the conclusions of others. For my own satisfaction, therefore, I undertook the following investigation of the coefficient of m^4, the calculation of which involves the whole mathematical question. For this purpose I have used the method of the variation of elements, which has already been applied by M. Delaunay; but as I have not had an opportunity of seeing what he has published on the subject, my own result is quite independent. It will be seen that the value which I obtain for the term in question agrees with that given by Professor Adams, the correctness of which no longer admits, in my mind, of any question. The process is quite elementary, and every step may be verified by any one who is moderately familiar

with the principles of Physical Astronomy. The latest publication which has reached me on the subject is that of M. de Pontécoulant, in the *Monthly Notices*, vol. xx. No. 9. The error of his calculation admits of being very briefly stated: it consists simply in the transposition of the symbols δ and d' in the first term of the formula (c), p. 355. If the original derivation of the formula be referred to, it will be seen at once that $\int \delta\, d' \mathrm{R}$ ought to be written instead of $\int d' \delta \mathrm{R}$. The effect of the transposition is, that all the non-periodic terms which exist in $\delta\, d' \mathrm{R}$ are lost. These terms are produced by integration, *when e' is treated as variable*, in forming the expression $\delta\, d' \mathrm{R}$; but no such terms can arise in $d' \delta \mathrm{R}$. If e' were treated as constant, the transposition of symbols would be immaterial. Thus we are brought back to the question whether e' is to be treated as constant or variable in integration. If any one persist in maintaining the former proposition, I do not think his opinion is likely to be affected by argument.

Neglecting the inclination, I denote by a, ϵ, e, ϖ, the variable elements of the Moon's orbit, viz. the major semiaxis, the mean longitude of the epoch, the excentricity, and longitude of perigee, of the instantaneous ellipse. The sum of the masses of the Earth and Moon being put $= 1$, n is defined by the equation $n^2 a^3 = 1$. The Moon's mean longitude is denoted by l, and defined by the equation $l = \int n\, dt + \epsilon$; so that, in forming the term $\frac{d\mathrm{R}}{da}$ in the value of $\frac{d\epsilon}{dt}$, the differentiation is not to affect n as contained in l. Accented letters refer to the Sun, and the elements of the Sun's orbit are supposed to be given functions of t.

It is convenient to choose n, ϵ, e, ϖ, as the four variables to be determined as functions of t. Then, since $\frac{dn}{dt} = -\frac{3}{2} a^{-\frac{5}{2}} \frac{da}{dt}$, we have, by the usual formulæ, neglecting e^2,

$$\frac{dn}{dt} = -\frac{3}{a^2}\frac{d\mathrm{R}}{d\epsilon}, \quad \frac{d\epsilon}{dt} = -2na^2\frac{d\mathrm{R}}{da} + \frac{1}{2}nae\frac{d\mathrm{R}}{de},$$

$$e\frac{de}{dt} = -na\frac{d\mathrm{R}}{d\varpi}, \quad e\frac{d\varpi}{dt} = na\frac{d\mathrm{R}}{de}.$$

If the disturbing function R be multiplied by a constant k, the value of which is finally to be put $= 1$, we may suppose the integral equations of this system to be developed in series proceeding by powers of k, of the form

$$n = \mathrm{n} + k\delta_1 n + k^2\delta_2 n + \ldots, \qquad \epsilon = \epsilon_0 + k\delta_1\epsilon + \ldots,$$

$$e = \mathrm{e} + k\delta_1 e + \ldots \qquad , \qquad \varpi = \varpi_0 + k\delta_1\varpi + \ldots,$$

in which n, ϵ_0, e, ϖ_0, are four arbitrary constants independent of k, and $\delta_1 n$, $\delta_2 n$, &c. are the parts of the variable elements due to the first, second, &c. powers of the disturbing force, and containing in general both periodic and non-periodic terms.

The Sun's mean motion being n', which may be considered as constant, I put $\frac{n'}{\mathrm{n}} = \mathrm{m}$, so that m is a constant.

The *observed mean motion* of the Moon is the non-periodic part of $\frac{d\,l}{d\,t}$, that is, of $n + \frac{d\,\epsilon}{d\,t}$: denoting this by N, I put $\frac{n'}{\mathrm{N}} = m$, so that m is variable because N is variable.

I denote by l the value of l corresponding to $k = 0$, that is $\mathrm{l} = \mathrm{n}\,t + \epsilon_0$; so that, putting $k = 1$, we may write

$$l = \mathrm{l} + \delta_1 l + \delta_2 l + \dots, \qquad \mathrm{N} = \mathrm{n} + \delta_1 . \frac{d\,l}{d\,t} + \delta_2 . \frac{d\,l}{d\,t} + \dots$$

in the last of which formulæ we are only to take the non-periodic parts of $\delta_1 . \frac{d\,l}{d\,t}$, &c.

It must be observed that the periodic terms which are integrated in the first approximation have, in general, arguments of the form $(i + \mathrm{m}\,i')\,\mathrm{n}\,t + \dots.$ But for the purpose of finding the non-periodic part of $n + \frac{d\,\epsilon}{d\,t}$ as far as $\mathrm{m}^4 e'^2$, the denominator introduced by integration may be always taken to be $i\,\mathrm{n}$, since the retention of the complete denominator would only introduce m^5, &c.

Putting $l - l' = \xi$, $l - \varpi = \phi$, $l' - \varpi' = \phi'$, we have, so far as is required for the present purpose,

$$\begin{aligned} R = n'^2 a^2 \Big\{ & \frac{1}{4} + \frac{3}{8} e'^2 + \left(\frac{3}{4} - \frac{15}{8} e'^2\right) \cos 2\xi \\ & - \left(\frac{1}{2} + \frac{3}{4} e'^2\right) e \cos \phi + \left(\frac{3}{4} - \frac{15}{8} e'^2\right) e \cos (2\xi + \phi) - \left(\frac{9}{4} - \frac{45}{8} e'^2\right) e \cos (2\xi - \phi) \\ & - \frac{3}{8} e' \cos (2\xi + \phi') + \frac{21}{8} e' \cos (2\xi - \phi') \\ & - \frac{3}{4} e e' \cos (\phi - \phi') + \frac{21}{8} e e' \cos (2\xi + \phi - \phi') + \frac{9}{8} e e' \cos (2\xi - \phi + \phi') \\ & - \frac{3}{4} e e' \cos (\phi + \phi') - \frac{3}{8} e e' \cos (2\xi + \phi + \phi') - \frac{63}{8} e e' \cos (2\xi - \phi - \phi') \Big\}. \end{aligned}$$

This expression comprises all terms of the first and second

orders in the excentricities, not multiplied by powers of $\frac{a}{a'}$, except one term involving $e' \cos \phi'$, and terms multiplied by e^2 or e'^2, which would be useless. The only terms required of the third order are those multiplied by $e\,e'^2$ with the same arguments as those of the first order multiplied by e. There can be no question about the correctness of the coefficients, which agree with those of M. de Pontécoulant (*Théorie Analytique*, t. iv. p. 58). I have, however, verified them all independently.

Putting $k = 0$, we should have $n = \mathrm{n}$, $\iota = \iota_0$, $e = \mathrm{e}$, $\varpi = \varpi_0$; and these values are to be substituted in the differential equations for the next approximation. Taking, first, the non-periodic part of R, we thus obtain (putting $k = 1$),

$$\frac{dn}{dt} = 0, \quad \frac{de}{dt} = 0, \quad \frac{d\varpi}{dt} = 0, \quad \frac{d\iota}{dt} = \frac{n'^2}{\mathrm{n}}\left(-1 - \frac{3}{2}e'^2\right);$$

whence

$$n = \mathrm{n}, \quad e = \mathrm{e}, \quad \varpi = \varpi_0, \quad \frac{d\iota}{dt} = -\mathrm{m}^2\mathrm{n}\left(1 + \frac{3}{2}e'^2\right),$$

and

$$\mathrm{N} = \mathrm{n}\left(1 - \mathrm{m}^2 - \frac{3}{2}\,\mathrm{m}^2 e'^2\right) \quad \ldots\ldots\ldots \quad (\mathrm{A}).$$

These are the only non-periodic terms depending on the first power of the disturbing force, and not involving e^2, &c., or e'^4, &c.

In the periodic part of R, it is convenient to take separately those terms which involve e, and those which do not. The latter are of the form

$$n'^2 a^2 p \cos(2\,l + \psi),$$

where p contains e' or e'^2, and ψ is independent of quantities referring to the Moon. The differential equations obtained from this term give

$$\left.\begin{aligned} \frac{d\iota}{dt} &= -4\frac{n'^2}{n}\,p\cos(2\,l + \psi), \\ \frac{dn}{dt} &= \quad 6\,n'^2\,p\sin(2\,l + \psi), \end{aligned}\right\} \quad \ldots\ldots \quad (1).$$

and, introducing in their right-hand members the values corresponding to $k = 0$, we have for a first approximation,

$$\frac{d\iota}{dt} = -4\,\mathrm{m}^2\mathrm{n}\,p\cos(2\,\mathrm{l} + \psi), \quad \frac{dn}{dt} = 6\,\mathrm{m}^2\mathrm{n}^2 p\sin(2\,\mathrm{l} + \psi).$$

In integrating these we are to consider p as variable, because it contains e'; but since $\frac{d e'}{d t}$ and $\frac{d . e'^2}{d t}$ may be regarded as constant, we may treat $\frac{d p}{d t}$ as constant also. Hence, integrating by parts, we obtain $\epsilon = \epsilon_0 + \delta_1 \epsilon$, $n = \mathrm{n} + \delta_1 n$, where

$$\delta_1 \epsilon = -2 \mathrm{m}^2 p \sin (2 \mathrm{l} + \psi) - \frac{\mathrm{m}^2}{\mathrm{n}} \frac{d p}{d t} \cos (2 \mathrm{l} + \psi),$$

$$\delta_1 n = -3 \mathrm{m}^2 \mathrm{n} p \cos (2 \mathrm{l} + \psi) + \frac{3}{2} \mathrm{m}^2 \frac{d p}{d t} \sin (2 \mathrm{l} + \psi);$$

From the latter expression we have, integrating again by parts,*

$$\int \delta_1 n . d t = -\frac{3}{2} \mathrm{m}^2 p \sin (2 \mathrm{l} + \psi) - \frac{3}{2} \frac{\mathrm{m}^2}{\mathrm{n}} \frac{d p}{d t} \cos (2 \mathrm{l} + \psi);$$

whence, observing that $l = \mathrm{l} + \delta_1 \epsilon + \int \delta_1 n . d t$, we have

$$\delta_1 l = -\frac{7}{2} \mathrm{m}^2 p \sin (2 \mathrm{l} + \psi) - \frac{5}{2} \frac{\mathrm{m}^2}{\mathrm{n}} \frac{d p}{d t} \cos (2 \mathrm{l} + \psi).$$

For the next approximation we are to resume the equations (1), putting in their right-hand members $\mathrm{n} + \delta_1 n$, $\mathrm{l} + \delta_1 l$, instead of n, l; hence, observing that $\frac{1}{n} = \frac{1}{\mathrm{n}} - \frac{1}{\mathrm{n}^2} \delta_1 n$, &c., and, taking only the non-periodic parts of the result, we obtain

$$\frac{d \epsilon}{d t} = -20 \mathrm{m}^4 \mathrm{n} p^2, \qquad \frac{d n}{d t} = -15 \mathrm{m}^4 \mathrm{n} p \frac{d p}{d t};$$

the latter equation gives, by integration, $\delta_2 n = -\frac{15}{2} \mathrm{m}^4 \mathrm{n} p^2$; hence, so far as this term in R is concerned, the non-periodic part of $\frac{d l}{d t}$, or of $n + \frac{d \epsilon}{d t}$, is $-\frac{55}{2} \mathrm{m}^4 \mathrm{n} p^2$.

If p be of the form $\alpha + \beta e'^2$, this gives (neglecting e'^4),

$$\delta_2 . \frac{d l}{d t} = -55 \mathrm{m}^4 \mathrm{n} \alpha \beta e'^2;$$

* The constant, which in strictness ought to be added, would not affect the result.

but if p be of the form $\alpha e'$, then

$$\delta_2 \cdot \frac{dl}{dt} = -\frac{55}{2} \mathrm{m}^4 \mathrm{n} \alpha^2 e'^2.$$

There is one term in R of the former kind, in which $\alpha = \frac{3}{4}$, $\beta = -\frac{15}{8}$; and two terms of the latter kind, in which $\alpha = -\frac{3}{8}$, and $\alpha = \frac{21}{8}$ respectively; hence the part of N arising from these terms is

$$55\left(\frac{45}{32} - \frac{9}{128} - \frac{441}{128}\right) \mathrm{m}^4 \mathrm{n} e'^2 = -\frac{7425}{64} \mathrm{m}^4 \mathrm{n} e'^2 \quad . \quad . \quad \text{(B)}$$

The remaining terms of R are of the form

$$n'^2 a^2 p e \cos(i l + j \varpi + \psi),$$

where p contains e'. The differential equations now become

$$\frac{dn}{dt} = 3 i n'^2 p e \sin(i l + j \varpi + \psi),$$

$$\frac{d\epsilon}{dt} = -\frac{7}{2} \frac{n'^2}{n} p e \cos(i l + j \varpi + \psi),$$

$$\frac{de}{dt} = j \frac{n'^2}{n} p \sin(i l + j \varpi + \psi),$$

$$\frac{d\varpi}{dt} = \frac{n'^2 p}{n e} \cos(i l + j \varpi + \psi).$$

Proceeding in the same way as before, we obtain from the last two equations

$$\delta_, \epsilon = -\frac{j}{i} \mathrm{m}^2 p \cos(i \mathrm{l} + j \varpi_0 + \psi) + \frac{j}{i^2} \frac{\mathrm{m}^2}{\mathrm{n}} \frac{dp}{dt} \sin(i \mathrm{l} + j \varpi_0 + \psi)$$

$$\delta \varpi = \frac{1}{i} \frac{\mathrm{m}^2 p}{\mathrm{e}} \sin(i \mathrm{l} + j \varpi_0 + \psi) + \frac{1}{i^2} \frac{\mathrm{m}^2}{\mathrm{ne}} \frac{dp}{dt} \cos(i \mathrm{l} + j \varpi_0 + \psi);$$

and putting $\mathrm{e} + \delta_, e$, $\varpi_0 + \delta_, \varpi$, for e, ϖ, in the first two, and observing that $\delta_, l$ and $\delta_, n$ would only give terms multiplied by e^2, so that we may put l for l and n for n, we find for the non-periodic parts

$$\frac{dn}{dt} = 3 \frac{j}{i} \mathrm{m}^4 \mathrm{n} p \frac{dp}{dt}, \qquad \frac{d\epsilon}{dt} = \frac{7}{2} \frac{j}{i} \mathrm{m}^4 \mathrm{n} p^2;$$

hence $\delta_2 n = \frac{3}{2}\frac{j}{i}\,\mathrm{m}^4\,\mathrm{n}\,p^2$, and the non-periodic part of $\frac{d\,l}{d\,t}$ is $5\,\frac{j}{i}\,\mathrm{m}^4\,\mathrm{n}\,p^2$. Hence, if p be of the form $\alpha + \beta\,e'^2$, we have

$$\delta_2 \cdot \frac{d\,l}{d\,t} = 10\,\frac{j}{i}\,\mathrm{m}^4\,\mathrm{n}\,\alpha\,\beta\,e'^2;$$

but, if p be of the form $\alpha\,e'$, then

$$\delta_2 \cdot \frac{d\,l}{d\,t} = 5\,\frac{j}{i}\,\mathrm{m}^4\,\mathrm{n}\,\alpha^2\,e'^2.$$

There are three terms in R of the former kind, in which

$$\begin{array}{llll}
\alpha = -\frac{1}{2}, & \beta = -\frac{3}{4}, & i = 1, & j = -1, \\
\alpha = \frac{3}{4}, & \beta = -\frac{15}{8}, & i = 3, & j = -1, \\
\alpha = -\frac{9}{4}, & \beta = \frac{45}{8}, & i = 1, & j = 1;
\end{array}$$

and the part of N, arising from these terms, is therefore,

$$10\left(-\frac{3}{8} + \frac{15}{32} - \frac{405}{32}\right)\mathrm{m}^4\,\mathrm{n}\,e'^2 = -\frac{8040}{64}\,\mathrm{m}^4\,\mathrm{n}\,e'^2 \quad . \; . \; . \quad (\mathrm{C})$$

There are six terms of the latter kind, in which

$$\begin{array}{llllll}
\alpha = -\frac{3}{4}, & i = 1, & j = -1; & \alpha = \frac{21}{8}, & i = 3, & j = -1; \\
\alpha = \frac{9}{8}, & i = 1, & j = 1; & \alpha = -\frac{3}{4}, & i = 1, & j = -1; \\
\alpha = -\frac{3}{8}, & i = 3, & j = -1; & \alpha = -\frac{63}{8}, & i = 1, & j = 1;
\end{array}$$

and the part of N, arising from these, is therefore

$$5\left(-\frac{9}{16} - \frac{147}{64} + \frac{81}{64} - \frac{9}{16} - \frac{3}{64} + \frac{3969}{64}\right)\mathrm{m}^4\,\mathrm{n}\,e'^2$$

$$= \frac{19140}{64}\,\mathrm{m}^4\,\mathrm{n}\,e'^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (\mathrm{D})$$

Adding the four terms (A), (B), (C), (D), we have finally

$$\mathrm{N} = \mathrm{n}\left(1 - \mathrm{m}^2 - \frac{3}{2}\,\mathrm{m}^2\,e'^2 + \frac{3675}{64}\,\mathrm{m}^4\,e'^2\right);$$

but this expression has still to be transformed into one, involving m $\left(\text{or } \frac{n'}{\mathrm{N}}\right)$ instead of m $\left(\text{or } \frac{n'}{\mathrm{n}}\right)$.

Let N_0, e'_0, be the values of N, e', when $t = t_0$, then (since m is independent of e'),

$$\mathrm{N} - \mathrm{N}_0 = \mathrm{n}\left(-\frac{3}{2}\mathrm{m}^2 + \frac{3675}{64}\mathrm{m}^4\right)(e'^2 - e'^2_0);$$

also

$$\frac{1}{\mathrm{N}} = \frac{1}{\mathrm{n}}(1 + \mathrm{m}^2 + \ldots);$$

hence, as far as the present approximation,

$$\frac{\mathrm{N} - \mathrm{N}_0}{\mathrm{N}} = \left(-\frac{3}{2}\mathrm{m}^2 + \frac{3579}{64}\mathrm{m}^4\right)(e'^2 - e'^2_0);$$

also, since $\frac{n'}{\mathrm{N}} = m$, we have

$$m = \mathrm{m}(1 + \mathrm{m}^2 + \ldots),$$

and

$$\mathrm{m} = m(1 - m^2 + \ldots);$$

whence

$$-\frac{3}{2}\mathrm{m}^2 = -\frac{3}{2}m^2 + 3m^4 + \ldots, \quad \text{and} \quad \mathrm{m}^4 = m^4 + \ldots;$$

introducing these values, we obtain

$$\mathrm{N} - \mathrm{N}_0 = \mathrm{N}\left(-\frac{3}{2}m^2 + \frac{3771}{64}m^4\right)(e'^2 - e'^2_0),$$

which agrees with the conclusion of Professor Adams.

It should be observed that the notation here used is not the same as that of M. de Pontécoulant, who uses n to denote what I have represented by N, namely, the mean motion of the Moon given by observation.

[With reference to M. de Pontécoulant's calculations, it may be remarked, in addition to what was said at the beginning of this paper, that the second term in his formula (c) is not in its original form, but is obtained by writing $\frac{1}{2}\left(\int d'\mathrm{R}\right)^2$ instead of $\int\left(d'\mathrm{R}\int d'\mathrm{R}\right)$. The latter form would give *no non-periodic term if e' were to be treated as constant;* and the non-periodic terms given by the transformation would be, on that supposition, nothing better than an arbitrary function of e', introduced as a constant in the integration. The transformation is, in fact, legitimate; but it is only so *because* e' is variable; and the non-periodic terms which it produces are precisely what would be obtained by applying the process of integration by parts in developing the form $d'\mathrm{R}\int d'\mathrm{R}$.]

Madeira, 27th May, 1861.

A communication has been received from M. de Pontécoulant, containing observations on M. Hansen's letter of the 2d Feb. 1861, to the Astronomer Royal, published in the March number of the *Monthly Notices*. M. de Pontécoulant remarks that in the lunar theory an *empirical* equation is one which is not founded on the rigorous principles of the law of gravitation, but is only introduced to make the results of calculation accordant with the observations; he is therefore surprised to see M. Hansen reckon in the class the motions of the perigee and node of the Moon's orbit, the determination of which motions is an obligatory condition of the theory. He thinks that M. Hansen has misapprehended the objection to Prof. Adams' method for the determination of the acceleration; and after remarking that it is at least presumable that there is no error or omission of terms in the calculations of Prof. Adams, confirmed as they are by the investigations of MM. Plana, Delaunay, and Lubbock, he continues as follows: "Si l'on veut donc regarder comme variable l'excentricité de l'orbite terrestre dans les équations du mouvement troublé de la Lune, ce qui parait en effet plus exact que de traiter cette excentricité comme une quantité constante, ainsi qu'on l'avait fait jusqu'à présent, et ce qui avait paru suffisant pour la comparaison des plus anciennes observations qui nous soient parvenus, il faudrait alors substituer dans les équations différentielles du mouvement troublé de la Lune à la place de e', qui répresente l'excentricité de l'orbite terrestre, sa valeur exprimée en série de *sinus* et de *cosinus* d'arcs proportionnels à la longitude vraie de la Lune si l'on se sert des formules de Laplace, et proportionnels à sa longitude moyenne si l'on fait usage des formules ordinairement employées dans la théorie des planètes, de même que l'on substitue dans ces équations les valeurs des autres co-ordonnés du Soleil developpées de la même manière avant d'opérer leur intégration. On arrivera ainsi à une exacte évaluation de *l'équation séculaire*, qui ne différera que très legèrement de celle que les géomètres ont obtenues en négligeant dans une première approximation les variations des éléments de l'orbe solaire, et qui répresenteront les plus anciennes observations dans les limites d'exactitude que comporte l'imperfection de ces observations et le long intervalle de temps qui nous en sépare. De toute autre manière on n'obtiendra que des résultats fautifs, &c."

As to the concluding part of M. Hansen's letter, M. de Pontécoulant remarks that the conditions under which M. Hansen will approve of the only method able to give a literal and analytical solution of the problem of perturbations, on a par with the perfection of the other parts of Celestial Mechanics, are conditions which it is impossible to comply with in a question so complicated and full of difficulties—and that M. Hansen's terms amount to a refusal to accept in the lunar theory any other solution than that by mechanical substitutions.

But M. de Pontécoulant asks if the convergence of the series needs to be established *à priori;* or whether it is not sufficiently proved by the results afforded by the series themselves, calculated to an extent which shows that no appreciable quantities are neglected; and by the accordance of the values of the coefficients as obtained by the series, and as laboriously deduced from many thousands of observations. And more than this, he appeals to M. Hansen himself, who has shown in the *Astronomische Nachrichten*, vol. xvii. p. 302, by reducing Damoiseau's expression for the mean longitude to the form made use of in M. Hansen's Tables, that there is a close agreement of the two expressions—while, on the other hand, M. de Pontécoulant in his Lunar Theory has shown that the coefficients obtained by the method of series accord with those of Damoiseau—and this comparison with the same mean term shows that the results obtained by M. Hansen are the reproduction in a different form of those given by the analytical method. M. de Pontécoulant states, also, that he has recently occupied himself with the converse question of the deduction of the expression for the true longitude from M. Hansen's expression of the disturbed mean anomaly, and that with two exceptions, which he reserves for further examination, he finds that the results entirely agree with those given by his own theory.

Observations of the Variable Star η Argus.
By Francis Abbott, Esq.

Passing by Sir John Herschel's observation on this very remarkable star in the year 1837, and when it attained its maximum in January 1838; also passing over the observations made by Sir Thomas Maclear at the Cape of Good Hope, and Mackay at Calcutta, in the year 1843, when *η Argus* surpassed *Canopus*, and nearly equalled *Sirius*, and preserved that brilliancy till the year 1850, when Lieut. Gillis, writing from Santiago, February 1850, describes it of a reddish yellow colour, darker than *Mars*, and nearly equal in brightness to *Canopus;* from these dates I give the following observations from my own journal:—

1856. In the early part of this year I compared *η Argus* with the united light of the two components of *α Centauri*, which it nearly equalled.

1858, Feb. 10th, a gradual diminution has taken place in the brightness of this star; it now only approximates to *β Crucis;* if any thing, rather inferior.

1858, March 6th, η *Argus* is comparable only to γ *Crucis*, the latter being of somewhat deeper colour and more sharply defined; the former dull and hazy.

1858, April 2d, to all appearance η *Argus* and γ *Crucis* are near alike both in size and colour.

1858, May 28th, η *Argus* gradually declining, γ *Crucis* being much the brighter of the two.

1858, Oct. 8th, γ *Crucis* decidedly very superior in splendour to η *Argus*.

1859, March 27th, ε *Argus* is now more sharply defined than η *Argus*, it being the nearest comparison star.

1859, July 6th, η and κ *Argus* are now about equal; the latter is estimated at 3d mag. = 3·35 of Herschel.

1860, Nov. 2d, δ *Crucis* is scarcely equal to η *Argus;* if anything more sharply defined; the latter looking sickly, as if dying out.

1861, March 21st, δ *Crucis* is certainly very superior to η *Argus*, being much more readily found in the fading twilight.

1861, April 8th, at this date η *Argus* has not more light than ε *Crucis*, the former having a faint milky appearance.

1861, April 13th, ε *Crucis* seen in the evening twilight 10 minutes before η *Argus*.

Private Observatory, Hobart Town.

On the Probable Identification of Anthelm's Variable of 1670 *(Nova Vulpeculæ), and on some other Variable Stars.* By J. R. Hind, Esq.

Early in the year 1852, I worked up the position of the star discovered by Anthelm in June, 1670, near the head of *Cygnus*, from the observations at p. 45 of Lémonnier's *Histoire Céleste*, which are probably the best that were made upon that object. The resulting place for 1850 is,

R.A. ...... $19^h 41^m 26^s \cdot 8$ N.P.D. ...... $63° 3' 24''$.

On the 24th of April, 1852, I found close upon this point a star of 10-11 magnitude, preceding Lalande 37730 by 25 seconds in R.A, and $23' \cdot 1$ south of it. Anthelm's star should precede about 27 seconds, with $23' \cdot 3$ greater N.P.D., thus presenting a close agreement. I had intended to keep a watch upon this star, but, my attention being then chiefly directed to planet-hunting, I neglected to do so.

On the 24th of May in the present year, I was surprised to find the star had diminished to the 12th magnitude; and this circumstance, taken in connexion with the near accordance in

position, leads me to conclude that it is really Anthelm's *Nova Vulpeculæ*, long reputed to have become extinct. To my eye there is a hazy, ill-defined appearance about it, which is not perceptible in other stars in the same field of view. Mr. Talmage, whose sight is remarkably strong, received the same impression; and I may add that Mr. Baxendell, who has examined it with Mr. Worthington's reflector, observed that no adjustment of the focus would bring the star up to a sharp point on the night of June 1. Mr. Baxendell's estimate of its present magnitude agrees precisely with mine; and as I am quite convinced I could never have called it 10-11 in any state of the sky, its variability I believe to be established.

The Greenwich 12-year Catalogue contains a star which was observed while looking for 11 *Vulpeculæ* of Flamsteed (Anthelm's *Nova*), and which, singularly enough, was also proved to be variable, as appears from the note to No. 1773. It follows the small star alluded to above, about 48 seconds in R.A.; and, fortunately, we are able to show that it has no proper motion to account for this difference in position since 1670, the star having been observed by Bessel in Zone 432, on the 17th of August, 1828—a fact to which Mr. Baxendell was kind enough to draw my attention. The Greenwich mean place for 1836·0 is,

R.A. ...... $19^h\,41^m\,40^s{\cdot}48$ N.P.D. ...... $63^\circ\,7'\,2''{\cdot}2$.

Bessel's observation brought up to the same epoch gives,

R.A. ...... $19^h\,41^m\,40^s{\cdot}42$ N.P.D. ...... $63^\circ\,7'\,2''{\cdot}6$.

From this fixity of position during eight years, it may be inferred that the Greenwich variable is distinct from Anthelm's, and an addition to our list of these mysterious objects.

It appears by no means improbable that, by carefully noting the relative brightness of the stars situated near the positions of the famous variables of 1572 and 1604, we may succeed in identifying them, and thus guard against a similar surprise to that experienced by Tycho on the sudden outburst of the star in *Cassiopea* in 1572. It might thus be possible, by assiduous and patient examination of the vicinity, to secure the ascending as well as the descending light-curve, which would assuredly prove of great value in the explanation of the phenomena of irregular stars. I am, of course, assuming that, like Anthelm's star—and, I may add, the one which became suddenly visible to the naked eye in *Ophiuchus* in April 1848, —they are varying perceptibly about an *average minimum*.*

* M. Arago, in his *Astronomie Populaire*, states that this star, which I detected on 1848, April 27, has quite disappeared. It is a mistake. The star has not descended below the 12th magnitude, and is rarely so faint, though I am satisfied there is an irregular variation to an extent, between extremes, of a whole magnitude, if not more.

The place of Tycho's variable, brought up to the beginning of 1850, is

R.A. ...... $0^h\ 16^m\ 18^s{\cdot}2$ N.P.D. ...... $26°\ 41'\ 55''$.

as I find by a new reduction of some of the measures of distances from stars, given in his treatise *De Stellâ Novâ Anni* 1572. His own place (R.A. and Decl.), brought up to the same date, would differ from the above $+5^s{\cdot}4$ in R.A. and $-1'{\cdot}2$ in N.P.D. On the 30th of August, 1848, I found two small stars near this position: one of 11-12 magnitude, in R.A. $0^h\ 16^m\ 20^s{\cdot}9$ and N.P.D. $26°\ 38'{\cdot}8$; the other, rather fainter, in R.A. $0^h\ 16^m\ 29^s{\cdot}4$ and N.P.D. $26°\ 42'{\cdot}0$. Perhaps the latter object is the more suspicious of the two, though both will require watching.

The place of Kepler's star, 1604, has been deduced from his observations by Dr. Winnecke (*Astron. Nach.* No. 1121). It is as follows, for 1850:—

R.A. ...... $17^d\ 25^m\ 49^s$ N.P.D. ...... $111°\ 15'$.

Singularly enough, on examining this part of the heavens in April, 1857, Dr. Winnecke found, in this case also, two small stars near the computed position: one of 11-12th magnitude, in R.A. $17^h\ 25^m\ 47^s$ and N.P.D. $111°\ 14'$; the other, a somewhat smaller star, in R.A. $17^h\ 25^m\ 45^s$ and N.P.D. $111°15'$; both stars are within the probable limits of error of Kepler's place.

On the Nomenclature of the Minor Planets.
By J. R. Hind, Esq.

In a note appended to M. Le Verrier's *Meteorological Bulletin* of the 18th of March last, attention is directed to the nomenclature of the group of planets between *Mars* and *Jupiter*, which is now so rapidly increasing in number; and it is suggested that, without continuing to give each planet a particular name, it may be a sufficient distinction to mention the number in order of discovery, attaching thereto the name of the discoverer: thus, *Astræa* would be (5) *Hencke; Thetis,* (17) *Luther; Ausonia,* (63) *Gasparis;* and so on. The opinions of those astronomers to whom the detection of these planets is due are invited by M. Le Verrier.

The objections to such a system of nomenclature as is here proposed appear, in my mind, so obvious and important, that I confess I read the remarks of the illustrious Director of the

Observatory of Paris with much surprise. It could not be brought into use at present, at any rate, without continual reference to a table in which the proper names now employed would be the argument, and the ordinal number and discoverer's name, together, the equation. No person, I imagine, depending upon his memory alone, could ensure the connexion of the right name with the right number: there would be continual mistakes, and we should be exposed to waste of time and trouble in deciding to what planet reference was intended to be made. Further, the true ordinal number for a planet may be in doubt for weeks or months, as the history of the discovery of these bodies has proved in several cases. Dr. Luther's last planet, *Leto*, has been repeatedly called (67) in the *Bulletins* and *Astronomische Nachrichten*, but Mr. Pogson's *Asia* is really (67); and the intelligence of his discovery of course upset the numbers which had been adopted in Europe. Instances of this kind are pretty sure to occur again.

I might trace the effects of the introduction of the proposed system further, but the two objections here advanced appear so strong and unavoidable that it may be unnecessary to dilate upon the subject. I must give a decided vote against a change which I believe, if effected, for a time would lead to confusion and useless trouble—ultimately causing a return, by general consent, to our present nomenclature.

It has been long understood amongst astronomers that names for the small planets shall be selected from those of classical antiquity. The advantage of adhering to this neutral foundation is clear enough, and I think it is to be regretted that in two or three cases an inclination to depart from it has been evinced. *Angelina* and *Maximiliana* ought, in my opinion, to be rejected, as inconsistent with the strict interpretation of the rule; or, if allowed, it should be on the understanding that no future infractions of that rule will be tolerated. This once acknowledged, a little care in the choice of names, euphonious and not liable to be confounded with others either in writing or pronunciation, would obviate the necessity of further discussion.

The view which I have taken is equally adopted by M. Goldschmidt, to whom we owe fourteen of these planets, and by Dr. Luther, who has discovered eleven. I may perhaps be allowed to add, without entering into particulars, that the Astronomer Royal and Sir John Herschel are as strongly opposed to the suggested innovation, and also our distinguished Associate, Professor Argelander.

There is one name, unobjectionable upon other grounds, which was proposed in America for Mr. Ferguson's last planet, but which had been previously appropriated by Sir John Herschel for the interior one of the two bright satellites of *Uranus*: I allude to *Titania*. Mr. Lassell has constantly used

this name in his published observations of this satellite, as may be seen from No. 813 of the *Astronomische Nachrichten*, and various numbers of the *Monthly Notices*. As it was probably selected for the planet by inadvertence, I will venture to express a hope that Mr. Ferguson will see the propriety of substituting another. *Pseudo-Daphne*, when recovered, will require a name, and (59) also, if our present system is to be continued; and I can neither directly nor indirectly favour its rejection.

Note on the Disposition of the Penumbra of a Solar Spot.
By W. R. Birt, Esq.

A spot that has recently entered on the Sun's disk has exhibited, in connexion with the phenomenon first observed and described by Dr. Wilson in 1769, an interesting disposition of the penumbra *on the side nearest the Sun's limb*, of such a character as to manifest, in the course of twenty-four hours, a distribution precisely the opposite of that described by the Doctor, in so far as the gradual appearance of the penumbra on the side furthest from the limb is concerned, that generally exhibiting, as observed by the Doctor, the smallest extent of penumbra.

1861, June $12^{d}\,22^{h}\,0^{m}$ G.M.T. A large spot with a well-defined nucleus had lately entered on the disk; the sides nearest and furthest from the limb were both destitute of penumbræ. A narrow strip of penumbra was seen between the nucleus and the limb. The margin of the nucleus furthest from the limb was sharp and well-defined.

1861, June $13^{d}\,5^{h}\,45^{m}$ G.M.T. A narrow fringe of penumbra on the side *furthest* from the limb; the luminous material of the photosphere *joining the margin* of the nucleus *nearest* the limb, the separate strip of penumbra between the nucleus having increased in size.

1861, June $13^{d}\,22^{h}\,0^{m}$. The fringe of penumbra on the side furthest from the limb increased in breadth, and wider than the penumbra nearest the limb, excepting the separate strip which has now a few small spots. The surface of the photosphere runs in between this strip and the main spot.

The spot now visible is an interesting instance of the combination of the gradual revelation of the penumbra hidden, according to Dr. Wilson, by the curvature of the solar globe with the disturbing effect of smaller spots in the neighbourhood of larger ones, of which he has given five instances. It would appear, from the sketches I made of the spot at its three

stages, that the force producing it acted from the eastward, considerably below the photosphere, in an *oblique* direction, and that the strip of penumbra, with its included small spots, resulted from this disturbing action, and not that the spots were the agents in depriving the nucleus of its penumbra, as suggested by Dr. Wilson.

On the Ring of Saturn. By W. Lassell, Esq.

The *Monthly Notice* for April contains an interesting observation of Mr. De La Rue of the shadow of the ring of *Saturn* crossing the ball. I have lately noticed the same thing, and it is remarkable that when the ring was nearly in the same position, on the 3d of August, 1849, it was so strikingly apparent that I made a drawing of the planet, of which I send an exact tracing, and entered the following remarks in my astronomical journal.

"The peculiar feature of this unequalled view was that the most minute, but extremely black shadow of the ring upon the ball was evidently *knotted or notched, conveying the idea of mountains upon the plane of the ring, intercepting portions of the thin line of shadow, and almost breaking it up into a line of dots.*"

[The underlining is in the original].

I do not find that I have published the observation before, possibly on account of its having been made in the middle of the recess of the Society, but I have slightly alluded to the appearance, *Monthly Notices*, vol. xi. page 19, in speaking of the "serrated" form of the shadow of the ring upon the ball.

As the position of *Saturn* at the respective times was almost exactly the same in respect of the proportion of the axes, and also the superior altitude of the Earth to that of the Sun above the plane of the ring, making the portion of shadow seen very nearly equal in both observations; they are strikingly confirmatory of each other, and indicate a real peculiarity of conformation of the ring.

Bradstones, Sandfield Park, near Liverpool,
22d May, 1861.

On the Ring of Saturn and on Jupiter's Satellites. By Capt. W. S. Jacob.

I have several times lately observed something of the same appearance in *Saturn* as that referred to by Mr. De La Rue, in the April Number, p. 177, especially on the 19th May, a drawing of which I send. My first impression was, that the outline of the shadow was decidedly irregular, though to a less extent than is shown in Mr. De La Rue's drawing; but, on more careful scrutiny, and when the definition was at the best, I was inclined to think that the phenomenon might possibly be an illusion, arising from a variation in the shade or tone of the shadow, by which the darker portions appeared to project beyond the rest; the power of the instrument and the state of atmospheric definition were, however, insufficient to allow of my satisfying myself thoroughly on this point. The instrument used was the very excellent 5-foot by Tully, known as the Smythian, of which I have the loan from Dr. Lee.

Jupiter's Satellites.

There have been occurring of late several eclipses or occultations of *Jupiter's* Satellites by each other; a rather curious and interesting phenomenon, though of little practical utility.

I observed one of I. by III. on April 12th, which appeared almost exactly central.

	h	m	s	
First contact at	7	31	0	Greenwich M.T.
Central conjunction about	7	44		

Clouds prevented the observation of the last contact.

Also, on 19th May, an occultation of II. by I. not quite central, yet so nearly so, that at the time of conjunction the combined figure appeared to be round.

	h	m	s
First contact	8	56	0
Last contact	9	4	22

At $8^h\ 58^m\ 10^s$ the axis of the oval formed by the combined bodies seemed to point at *Jupiter's* upper or S. Limb, and at $9^h\ 2^m\ 40^s$ at the N. Limb.

The power employed was 180.

Hartwell, 2d June, 1861.

Note on an Appearance observed on Jupiter, by Mr. Birt, March 22, 1861. By J. Baxendell, Esq.

The appearance on *Jupiter* described by Mr. Birt at page 176 of the April number of the *Monthly Notices* was observed and sketched at Mr. Worthington's Observatory on the 17th of March last, and from observations made between that date and the 10th of April it was found that it returned to the same position on the disk of the planet in a period of $9^{h}\ 55^{m}\ 41^{s}\cdot4$ mean solar time. As this agrees very nearly with the best determinations of the planet's period of rotation, we may venture to give an answer in the negative to Mr. Birt's question, "Was this an instance of a rapid propagation of cloud in the atmosphere of the planet?"

On the 10th of April a faint and narrow streak was observed lying across the bright equatoreal belt in a N.P. and S.F. direction, its lower or northern end resting upon the large northern dark belt immediately above the "ragged portion," referred to by Mr. Birt, and its upper end nearly, if not quite, touching the southern dark belt. These projections upon, and sometimes quite across, a bright belt from parts of a dark belt where unusual action is going on are not of unfrequent occurrence, but do not seem to have hitherto received the attention which they appear to merit. Probably, however, this is owing to their faintness, and the difficulty of seeing them very distinctly except with telescopes of large aperture.

Manchester, May 25, 1861.

Results of Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of May, 1861.

(*Communicated by the Astronomer Royal.*)

Iris ⑦.

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, May 4	12 29 55·4	15 21 23·15	112 40 13·69
13	11 45 39·8	15 12 29·27	111 56 7·37
14	11 40 44·5	15 11 29·70	111 50 53·23
17	11 26 0·3	15 8 32·81	111 34 54·66
18	11 21 6·3	15 7 34·54	111 29 36·16
21	11 6 27·1	15 4 42·56	111 13 16·79
24	10 51 53·8	15 1 56·60	110 56 47·09
25	10 47 4·1	15 1 2·65	110 51 23·60

Panopea (70).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, May 14	11 3 39·0	14 34 18·17	104 26 3·67

The observations of *Iris* in N.P.D. have been corrected both for refraction and parallax; that of *Panopea* has been corrected for refraction only.

Occultation of B. A. C. 4006 by the Moon.

1861, May 19. The disappearance at the Moon's dark limb was observed by Mr. Dunkin to take place at $8^h\ 53^m\ 32^s{\cdot}2$ Mean Solar Time.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1861.			h m s	
May 13	I	Eclipse, reapp.	11 13 18·9	C.
17	II	Egress, bisection (*a*)	9 47 47·3	E.
25	III	Ingress, first cont.	8 24 24·2	K.
25	III	Ingress, bisection	8 26 53·8	K.
25	III	Ingress, last cont.	8 29 53·3	K.
26	II	Eclipse, reapp.	10 1 37·5	E.

(*a*), Unsatisfactory, the images being extremely tremulous.

The initials, E., C., and K., are those of Mr. Ellis, Mr. Criswick, and Mr. Kerschner.

Occultation of Mars by the Moon, observed at the Dudley Observatory, 1861, May 12. By O. M. Mitchel, Jun.

(*Communicated by Professor O. M. Mitchel through the Astronomer Royal.*)

Phenomenon.	Sidereal Time of Observation.
	h m s
Disappearance	11 0 46·7
Last Contact	12 1 28·8

Very hazy; observations satisfactory, however.

Occultation observed at Highbury. By T. W. Burr, Esq.

1861, May 19th. The star B.A.C. 4006 disappeared instantaneously at the dark limb of the Moon at $12^h 42^m\ 56^s{\cdot}7$, local sidereal time. The reappearance was not seen. Telescope 4 ft. 4 in. refractor; $3\frac{1}{8}$ inches aperture. Power 173. Longitude 24^s W.

Elements of Minor Planet (66).

(*Communicated by Prof. Bond.*)

Mr. Hall finds the following elements for the new asteroid (66), which has received the name of *Maia*, confirmed by Hon. Josiah Quincy, the venerable ex-President of Harvard College:

Epoch, 1861, May 16·35748, Washington M.T.

M	$139^\circ\ 27'\ 11''\!.9$	
ϖ	$43\ 54\ 5.7$	Mean Equinox, 1861·0.
☊	$8\ 11\ 41.7$	
i	$3\ 4\ 8.8$	
φ	$8\ 52\ 19.5$	
Log a	0·423879	
μ	$820''\!.71$	

By reason of the date of the discovery by Mr. Pogson of the Minor Planet *Asia* the numbers of the last four Minor Planets are:—

(67) *Asia*, Mr. Pogson.
(68) *Leto*, Dr. Luther.
(69) .. M. Schiaparelli.
(70) *Panopea*, M. Goldschmidt.

Places of Comet I. 1861. By N. M. R. Edmondson, Assistant, Armagh Observatory.

G.M.T.	R.A. h m s	Par. in R.A. s	N.P.D. ° ′ ″	Par. in N.P.D. ″
May 10·4443	8 56 21·22	$+\varpi\times$0·0390	67 28 33·56	$-\varpi\times$0·6656
12·4252	8 44 47·49	0·0369	73 59 47·97	0·7155
14·4563	8 34 39·98	0·0391	79 55 40·40	0·7853

Stars.	Comparisons.	Assumed Places.
77 Cancri	5	Armagh Catalogue.
63 ,,	5	,,
36 ,,	4	,,

Elements and Ephemeris of Comet I. 1861. By Dr. C. F. Pape.

Elliptic Elements from April 10, May 1 and 2, and May 18.

T = June 3·22854 Mean Berlin Time.

ϖ =	$243^\circ\ 3'\ 15''\!.2$	Mean Equinox 1861·0
☊ =	$29\ 51\ 9.8$	
i =	$79\ 55\ 3.7$	
log e =	9·997335	
log q =	9·964536	
log a =	2·177951	

Period = 1848·9 years.

Ephemeris for 0^h Mean Berlin Time, available for Mean Equinox.

1861.	R.A. ° ′	Decl. ° ′	Log r (Sun).	Log Δ (Earth).	Brightness.	Rises before Sun. h
July 21	104 23·5	34 4·8	0·09320	0·16443	0·25	3·7
23	104 1·5	34 30·8				
25	103 39·3	34 57·3	0·10861	0·17246	0·22	4·1
27	103 16·6	35 24·3				
29	102 53·4	35 52·0	0·12390	0·17922	0·20	4·4
31	102 29·5	36 20·3				
Aug. 2	102 4·8	36 49·2	0·13901	0·18479	0·18	4·7
4	101 38·9	37 18·6				
6	101 11·8	−37 48·6	0·15377	0·18927	0·17	5·0

The brightness is assumed = 1·0 on April 10, when the Comet was about 6 mag. The rising of the Comet is calculated for the latitude of the Cape Observatory.

Altona, June 4, 1861.

Observations of Comet I. 1861, *made with the Olcott Meridian Circle, at the Dudley Observatory.* Observed by G. W. Hough.

(*Communicated by Professor O. M. Mitchel through the Astronomer Royal.*)

Date.	Mean Time of Obs. h m s	App. R.A. h m s	App. Decl. ° ′ ″
April 11	15 38 38·57	17 0 45·51	+6c 21 25·37
17	14 19 58·29	16 4 12·61	65 7 16·73
19	13 39 22·98	15 32 42·77	66 34 3·16
24	11 22 40·44	13 35 20·54	67 45 20·68
25	10 50 16·98	13 6 48·31	67 10 47·57
26	10 17 42·63	12 38 5·17	+66 13 3·54

The Declinations are corrected for refraction, but not parallax.

The Right Ascensions are the mean of fifteen wires, with the exception of April 17th, when only two were observed.

April 25th, Strong moonlight; Comet very difficult to observe.

Prof. Bond, in a letter dated Observatory of Harvard College, 4th June, 1861, addressed to Mr. Carrington, writes as follows:—

I notice, in the *Monthly Notices* for April, that Mr. Thatcher

communicates an observation of the Comet I., 1861, to the Astronomer Royal, as follows:—

1861, April 10, $11^h 32^m 42^s$.

R.A. $17^h 7^m 42^s{\cdot}76$ Decl. $+59° 30' 8''$.

The observation intended is evidently that made at Cambridge on the 10th, appropriated, as it is printed in the *Notices*, *without* an acknowledgment, and *with* two important errors. The time is Cambridge, not New York time; and the declination should read

$+59° 28' 12''{\cdot}8$.

The right ascension is more precisely

$17^h 7^m 42^s{\cdot}60$,

as reported to you in my letter of the 25th April.

The correction is of some consequence, as the position is one of the earliest obtained of the Comet.

Capt. Shea continues with regularity, and sends to the Society, the Observations of Solar Spots which he has been engaged on for several years past.

Accounts have been received of the large Comet which has recently appeared. Mr. Burder, in a letter dated Clifton, June 30, 1861, 4 P.M., addressed to the Secretary of the Society, writes:—

"I saw a Comet at $2^h 40^m$ A.M. to-day,* and lost sight of it (through the approach of daylight) at $3^h 20^m$ A.M. It was as bright as *Capella*. It had no tail that I could see, but it had a bright nucleus surrounded by a nebulous haze.

"Its azimuth at $3^h 10^m$ A.M. was about 39° east of north, and its altitude about 10°, both *very rough* observations, as I had not time to apply instruments; or rather was afraid to run the risk of losing the object in the increasing daylight while preparing them. I therefore made the best of neighbouring buildings, the position of which I measured afterwards."

Mr. Stothard, in a letter dated Dublin, July 1st, 1861, writes:—

"On last evening (June 30th), about 10 o'clock P.M., Dublin time, as I was closing my instrument, after an observation of *Jupiter*, I was very much surprised at seeing a remarkable-looking nebulosity in the full glare of the twilight, in the north-west part of the heavens, which twilight was then so great as to render invisible all stars in those regions nearly as far as the zenith. I soon perceived in the object a distinct and

* Viz. on the *morning* of June 30.—Ed.

planetary-looking nucleus, which was well seen in an opera-glass, and shone out like the disk of a planet seen with a low power with a dense halo round it.

"This halo I found to be of a semi-lunar form, the convexity being in the direction of the Sun. I saw this well both in a large opera-glass and in my $2\frac{1}{2}$-inch achromatic, with the lowest power I have, an erecting eye-piece of 22.

"As the twilight faded, the tail came out; but, although I watched until midnight, the night was not dark enough to show it well.

"I could not help thinking that, had it been a dark season of the year, and the Comet been higher in the sky, it would have been one of the most remarkable seen for many years, larger, and I should say (under the same circumstances) more brilliant, than that of 1858 (Donati's).

"The Comet at midnight was almost due north, and must have been in or near the constellation *Auriga;* but I could not see the stars in that neighbourhood with the unaided eye. I did see one with the $2\frac{1}{2}$-inch refractor, a little lower, and following. Its altitude was low at 12^h.

"The suddenness of its apparition, together with its size and brilliancy, is remarkable.

"I have no doubt, from these two latter qualities, size and brilliancy, that it must have been visible for some time in these latitudes; but as yet we have heard nothing about it here."

Mr. Tidmarsh, in a letter dated Downside College, Bath, July 1st, 1861, calls attention to a splendid Comet, "which has been visible here during the night in the constellation of *Auriga,* situated at present about as far from β *Aurigæ* as that star is distant from *Capella,* and about the same north declination as *Capella.*

"The nucleus is very large and bright, and was distinctly visible to the naked eye as a Comet before half-past nine o'clock, P.M.

"It passed its lower transit at about ten minutes past midnight, and the huge tail then extended at least sixty or seventy degrees across the heavens. It could be distinctly traced across *Polaris,* and considerably beyond, nearly in the direction of *Vega.*"

The following observation, made with the transit-circle at the Royal Observatory, Greenwich, by W. J. Carpenter, has also been received:—

	Greenwich M.T.	App. R.A.	App. N.P.D.
1861, June	$30^d\ 12^h\ 5^m\ 53^s.9$	$6^h\ 42^m\ 1^s.48$	$43^\circ\ 0'\ 8''.2$.

The N.P.D. is corrected for refraction.

Daily motion in R.A. .... $+48^m$ } Approximate.
" " N.P.D. .... -8° }

ERRATA.

Page 211, line 26 from top, *for* third, *read* first.
— 214, — 29 — *for* a point on the other, *read* one or the other.
— — — 12 from bottom, *for* desk, and bottom line *for* disk, *read* dish.
— 215, lines 16, 17 from top, *for* pen A *and* pen B, *read* bar A *and* bar B.
— — line 19 from top, *for* instantaneously, *read* simultaneously.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI. *Supplemental Notice.* No. 9.

On the Positions of the Radcliffe Catalogue. By T. H. Safford, Assistant at the Observatory of Harvard College.

(*Communicated by Prof. Bond.*)

The differences given by the editor, the Rev. R. Main (*Radcliffe Catalogue*, p. v.) between the *Radcliffe* and the *Twelve-Year Catalogue*, can be approximately represented by the following formula:—

$$\text{Diff. of R.A. (Green. 12-Year C.} - \text{Rad.)} = -0^{s}{\cdot}038 + 0^{s}{\cdot}032 \sin (a + 5^{h}\ 32^{m}),$$

where a is the Right Ascension.

The remaining discrepancies are

R.A.	(Form.—Obs.)	R.A.	(Form.—Obs.)	R.A.	(Form.—Obs.)
h	s	h	s	h	s
0	−0·006	8	−0·004	16	−0·004
1	−0·007	9	−0·011	17	−0·016
2	+0·050	10	+0·024	18	−0·008
3	+0·024	11	+0·021	19	−0·009
4	−0·032	12	+0·030	20	+0·008
5	−0·030	13	+0·011	21	+0·005
6	−0·018	14	+0·004	22	0·000
7	−0·017	15	−0·030	23	+0·013

These remaining differences, although in some instances large, do yet change sign very frequently, and it will be observed that their mean between 10^{h} and 15^{h} is only $+0^{s}{\cdot}010$, whereas the mean of the original discrepancies deduced by Mr. Main between the same limits was $0^{s}{\cdot}05$ after subtracting the difference ($0^{s}{\cdot}038$) of equinoxes.

In investigating the causes which would give rise to such systematic discrepancies, I was first struck with the fact that

the same, or nearly the same, variations were apparent in the assumed places of the time-stars, for years since 1845; that, if correct positions of time-stars had been assumed, the resulting positions would have been free from these small errors.

To prove this it is only necessary to adduce the comparisons made.

Denoting by A the positions (for Radcliffe time-stars) of the *Twelve-Year Catalogue* for 1845; by B, the assumed places for the same year (*Radcliffe Observations*, vol. vi. p. vii.) of the same stars; and by C, the results of that year's observations at the Radcliffe Observatory, we have on the average:—

Hours of R.A.	B—A.	C—B.	C—A.	No. Stars.	No. Obs.
0 to 9	+0·019	—0·002	+0·017	43	174
10 „ 15	+0·074	—0·000	+0·064	15	62
16 „ 23	+0·023	—0·001	+0·025	36	118

The weights given to the numbers in the second and third columns only, are proportional to the number of observations. The discrepancy is apparent enough, but it is nearly the same in C as B; showing that the observations of 1845 neither increased nor diminished to any sensible amount the discrepancy which already existed in the places of the time-stars. There is a slight casual non-agreement between (B — A) + (C — B) and (C — A), owing to the different weights allowed.

So far as the second column (C—B) is concerned, a similar investigation showed much the same results for every year between 1840 and 1844. The year 1840, it is true, gave a value of about $+0^s\!\cdot\!015$ between 10^h and 15^h for C—B. This probably contributed somewhat to the variations apparent in the time-stars of the following years, but a similar amount did not again appear; but the *Nautical Almanac* places for 1840, compared with the *Twelve-Year Catalogue* places for the same year, exhibit the following differences in the mean:—

Hours.	B—A.
0 to 9	+0·077
10 „ 15	+0·093
16 „ 23	+0·083

This, so far as it is not constant, is entirely owing to the proper motions of the *Nautical Almanac* stars, which were generally neglected until 1848.

These yearly proper motions are, on the average (making that of stars for which they were taken into account in 1840 = 0):—

Hours.	s
0 to 9	+0·004
10 „ 15	+0·001
16 „ 23	+0·004

so that this error, which is contained in the Radcliffe time-stars, may have increased the variations in question.

In fact there is a tendency, in all proper motions in R.A., to be less (positively) between $10^h - 15^h$, or about these limits, than for other right ascensions; so that, not only the places of *Nautical-Almanac* stars, but those of other stars, will be somewhat erroneous, systematically, in this way, if computed without proper motion.

But why can errors of this kind remain, as we have seen that they do, in the results of observations? It would seem that they must be diminished by observing many stars together, and correcting their right ascensions mutually.

Suppose that N time-stars are observed in one day; that their right ascensions are a, $a+\beta$, $a+\beta'$, &c., and that these stars are equally used for the clock-errors. If a discrepancy of the form

$$m + n \sin a + p \cos a$$

exist, its effect upon the clock-errors for that day will be

$$m + \frac{n\,\{\sin a + \sin(a+\beta) + \sin(a+\beta') + \&c.\}}{N}$$

$$+\, p\,\frac{\{\cos a + \cos(a+\beta) + \cos(a+\beta') + \&c.\}}{N};$$

or, expanding

$$m + n \sin a\,\frac{(1 + \cos\beta + \cos\beta' + \&c.)}{N}$$

$$+\, p \cos a\,\frac{(1 + \cos\beta + \cos\beta' + \&c.)}{N}$$

$$-\, p \sin a\,\frac{(\sin\beta + \sin\beta' + \&c.)}{N}$$

$$+\, n \cos a\,\frac{(\sin\beta + \sin\beta' + \&c.)}{N};$$

and this will be a resulting error in the observed place, for that night, of the star whose right ascension is a.

Let the same star be observed again, in other groups. The mean of all the quantities represented by $\sin\beta$ will be very nearly $= 0$; because every time-star will be compared with many stars on each side of it, so that many of the quantities represented by β will be positive, and many negative.

But, on the other hand, if β be always small (less than

6 hours in almost all cases), the value of its cosine will be positive, and that of $\frac{1 + \cos\beta + \cos\beta' + \&c.}{N}$ will be nearly $= 1$, including, as it must, many instances in which the stars compared are within an hour or two of each other.

The effect of this will be (as we have seen in the *Radcliffe Observations*) to perpetuate any small systematic discrepancy of this kind.

But systematic differences depending on the declination tend to destroy themselves, unless the form of the pivots of the transit-instrument be erroneous.

I am, however, disposed to lay most stress upon the observed fact that the results of the *Radcliffe Observations* do, so far as the discrepancy in question is concerned, agree essentially with the assumed places of time-stars.

Hence it does not seem probable that the discrepancies in question have arisen from any instrumental error or error of observation, at least to the amount which they have reached.

Mr. Auwers, of Königsberg, has given (*Astr. Nachr.*, No. 1300) the following formula for correcting the Radcliffe *declinations*, so as to make them agree with Wolfers' *Tabulæ Reductionum*:—

$$\Delta\delta = -4''\cdot27 + 0''\cdot0647\,\delta^{\circ}.$$

I have tabulated these values with changed sign, so as to make them apply to N.P.D., and placed opposite them Mr. Johnson's own corrections:—

N.P.D.	Formula, Auwers.	Mr. Johnson's Correction.
°	"	"
0	−1·55	+0·92
10	−0·91	+1·03
20	−0·26	+1·15
30	+0·39	+1·28
40	+1·04	+1·38
50	+1·68	+1·46

These differ largely, and it is perhaps doubtful whether Mr. Auwers intended his formula to apply within 30° N.P.D. On the other hand, Wolfers' investigation (*Astr. Nachr.*, No. 1181) shows a general agreement between the Radcliffe *corrected* places and his own declinations.

Ephemeris of Encke's Comet. Calculated by Prof. Encke, and Communicated by the Astronomer Royal.

(For Berlin Mean Noon.)

1861.	R.A. h m s	Decl. ° ′ ″	Log Δ.	Log r.
Oct. 3	0 22 35·05	+18 59 53·1	0·044417	0·319852
4	20 13·79	53 28·2	0·040352	0·317687
5	17 50·40	46 36·7	0·036381	0·315502
6	15 25·01	39 18·6	0·032507	0·313295
7	12 57·78	31 34·1	0·028732	0·311067
8	10 28·85	23 23·0	0·025061	0·308817
9	7 58·39	14 45·7	0·021497	0·306544
10	5 26·55	+18 5 42·2	0·018043	0·304249
11	2 53·53	+17 56 13·1	0·014701	0·301931
12	0 0 19·47	46 18·6	0·011474	0·299589
13	23 57 44·57	35 59·2	0·008365	0·297224
14	55 8·99	25 15·5	0·005375	0·294834
15	52 32·93	14 8·2	0·002507	0·292420
16	49 56·57	+17 2 37·8	9·999761	0·289980
17	47 20·09	+16 50 45·3	9·997139	0·287515
18	44 43·67	38 31·3	9·994642	0·285023
19	42 7·51	25 56·9	9·992271	0·282505
20	39 31·78	+16 13 3·0	9·990026	0·279960
21	36 56·67	+15 59 50·6	9·987906	0·277388
22	34 22·37	46 20·9	9·985913	0·274787
23	31 49·07	32 35·1	9·984045	0·272158
24	29 16·95	18 34·4	9·982301	0·269500
25	26 46·18	+15 4 20·1	9·980681	0·266812
26	24 16·92	+14 49 53·5	9·979182	0·264093
27	21 49·35	35 16·1	9·977803	0·261344
28	19 23·63	20 29·1	9·976542	0·258564
29	16 59·90	+14 5 34·1	9·975395	0·255571
30	14 38·31	+13 50 32·4	9·974361	0·252906
31	12 19·01	35 25·5	9·973435	0·250027
Nov. 1	10 2·13	20 14·8	9·972615	0·247114
2	7 47·80	+13 5 1·7	9·971897	0·244167
3	5 36·14	+12 49 47·5	9·971276	0·241184
4	3 27·24	34 33·7	9·970748	0·238164
5	23 1 21·21	19 21·7	9·970309	0·235107
6	22 59 18·11	+12 4 12·6	9·969955	0·232013
7	57 18·00	+11 49 7·7	9·969680	0·228880
8	55 20·96	34 8·0	9·969479	0·225708
9	22 53 27·05	+11 19 14·5	9·969341	0·222495

1861.	R.A. h m s	Decl. ° ′ ″	Log Δ.	Log r.
Nov. 10	22 51 36·31	+11 4 28·3	9·969281	0·219240
11	49 48·79	+10 49 50·6	9·969273	0·215943
12	48 4·51	35 22·2	9·969320	0·212603
13	46 23·48	21 4·0	9·969415	0·209219
14	44 45·71	+10 6 56·8	9·969555	0·205790
15	43 11·21	+ 9 53 1·3	9·969734	0·202314
16	41 39·97	39 18·0	9·969947	0·198791
17	40 12·00	25 47·6	9·970189	0·195219
18	38 47·28	+ 9 12 30·5	9·970456	0·191598
19	37 25·80	+ 8 59 27·2	9·970743	0·187926
20	36 7·55	46 38·2	9·971044	0·184201
21	34 52·49	34 3·9	9·971355	0·180423
22	33 40·61	21 44·6	9·971672	0·176589
23	32 31·87	+ 8 9 40·6	9·971990	0·172699
24	31 26·23	+ 7 57 52·2	9·972304	0·168751
25	30 23·67	46 19·6	9·972609	0·164744
26	29 24·14	35 3·0	9·972902	0·160675
27	28 27·59	24 2·7	9·973177	0·156544
28	27 33·98	13 18·5	9·973432	0·152349
29	26 43·26	+ 7 2 50·5	9·973660	0·148088
30	25 55·37	+ 6 52 38·7	9·973857	0·143758
Dec. 1	25 10·25	42 42·9	9·974020	0·139358
2	24 27·85	33 3·0	9·974144	0·134886
3	23 48·10	23 39·0	9·974224	0·130340
4	23 10·93	14 30·7	9·974257	0·125718
5	22 36·27	+ 6 5 37·8	9·974239	0·121018
6	22 4·05	+ 5 57 0·1	9·974163	0·116236
7	21 34·18	48 37·2	9·974028	0·111371
8	21 6·59	40 28·8	9·973829	0·106419
9	20 41·19	32 34·3	9·973562	0·101379
10	20 17·89	24 53·4	9·973224	0·096247
11	19 56·61	17 25·7	9·972811	0·091020
12	19 37·25	10 10·5	9·972319	0·085696
13	19 19·73	+ 5 3 7·2	9·971744	0·080271
14	19 3·95	+ 4 56 15·2	9·971083	0·074741
15	18 49·82	49 33·8	9·970331	0·069104
16	18 37·23	43 2·4	9·969486	0·063355
17	18 26·08	36 40·2	9·968543	0·057490
18	18 16·26	30 26·3	9·967498	0·051506
19	18 7·68	24 19·9	9·966349	0·045398
20	18 0·23	18 20·1	9·965088	0·039161
21	17 53·79	12 26·2	9·963714	0·032791
22	22 17 48·23	+4 6 36·9	9·962223	0·026282

1861.	R.A. h m s	Decl. ° ′ ″	Log Δ.	Log *r*.
Dec. 23	22 17 43·42	+ 4 0 51·1	9·960610	0·019630
24	17 39·22	+ 3 55 7·4	9·958870	0·012828
25	17 35·46	49 24·8	9·956999	0·005872
26	17 31·99	43 41·6	9·954992	9·998754
27	17 28·66	37 56·5	9·952845	9·991470
28	17 25·29	32 7·8	9·950553	9·984011
29	17 21·69	26 13·7	9·948110	9·976371
30	17 17·64	20 12·0	9·945512	9·968543
31	22 17 12·90	+ 3 14 0·1	9·942752	9·960517
1862.				
Jan. 1	22 17 7·22	7 35·8	9·939826	9·952287
2	17 0·33	+ 3 0 56·7	9·936727	9·943843
3	16 51·96	+ 2 53 59·4	9·933452	9·935177
4	16 41·73	46 40·4	9·929993	9·926279
5	16 29·28	38 55·9	9·926346	9·917138
6	16 14·25	30 42·0	9·922506	9·907744
7	15 56·23	21 54·3	9·918468	9·898088
8	15 34·72	12 27·6	9·914227	9·888158
9	15 9·19	+ 2 2 15·9	9·909780	9·877942
10	14 39·08	+ 1 51 13·1	9·905123	9·867429
11	14 3·78	1 39 12·2	9·900254	9·856605
12	13 22·60	1 26 5·3	9·895173	9·845459
13	12 34·78	1 11 43·5	9·889880	9·833982
14	11 39·45	0 55 57·0	9·884376	9·822160
15	10 35·62	0 38 34·9	9·878665	9·809979
16	9 22·25	+ 0 19 25·1	9·872759	9·797434
17	7 58.22	− 0 1 45·9	9·866673	9·784517
18	6 22·30	0 25 12·4	9·860427	9·771224
19	4 33·19	0 51 10·9	9·854045	9·757552
20	2 29·43	1 19 58·8	9·847563	9·743504
21	22 0 9·44	1 51 54·8	9·841029	9·729091
22	21 57 31·62	2 27 18·2	9·834500	9·714331
23	54 34·39	3 6 29·1	9·828055	9·699255
24	51 16·21	3 49 47·1	9·821789	9·683909
25	47 35·62	4 37 29·3	9·815818	9·668353
26	43 31·43	− 5 29 50·6	9·810283	9·652686
27	39 2·96	6 26 59·4	9·805347	9·637011
28	34 10·13	7 28 56·3	9·801202	9·621484
29	28 53·80	8 35 30·7	9·798055	9·606292
30	23 16·07	9 46 18·1	9·796119	9·591673
31	17 20·34	11 0 37·3	9·795613	9·577897
Feb. 1	11 11·67	12 17 30·1	9·796724	9·565284
2	21 4 56·87	13 35 40·9	9·799611	9·554178
3	20 58 43·64	−14 53 45·1	9·804343	9·544931

1862.		R.A. h	m	s	Decl. °	′	″	Log Δ.	Log r.
Feb.	4	20	52	40·93	−16	10	11·2	9·810924	9·537878
	5		46	57·94	17	23	29·7	9·819265	9·533303
	6		41	42·87	18	32	23·6	9·829186	9·531399
	7		37	2·66	19	35	53·2	9·840441	9·532254
	8		33	2·33	20	33	18·8	9·852742	9·535827
	9		29	44·52	21	24	23·3	9·865784	9·541967
	10		27	9·75	22	9	7·3	9·879280	9·550414
	11		25	16·66	22	47	45·7	9·892977	9·560853
	12		24	2·54	23	20	43·5	9·906654	9·572933
	13		23	23·86	23	48	30·0	9·920146	9·586304
	14		23	16·54	24	11	38·1	9·933327	9·600637
	15		23	36·57	−24	30	39·9	9·946111	9·615640
	16		24	19·94		46	5·4	9·958442	9·631064
	17		25	23·08	24	58	21·8	6·970288	9·646703
	18		26	42·66	25	7	54·1	9·981637	9·662392
	19		28	15·86		15	4·0	9·992488	9·678001
	20		30	0·17		20	10·7	0·002849	9·693434
	21		31	53·51		23	30·2	0·012736	9·708618
	22		33	54·11		25	16·6	0·022169	9·723503
	23		36	0·41		25	42·5	0·031168	9·738051
	24		38	11·09		24	58·6	0·039752	9·752240
	25		40	25·09		23	14·1	0·047944	9·766056
	26		42	41·51		20	36·9	0·055766	9·779494
	27		44	59·61		17	13·7	0·063237	9·792554
	28		47	18·79		13	10·2	0·070377	9·805242
Mar.	1		49	38·49		8	31·8	0·077203	9·817560
	2		51	58·24	−25	3	23·4	0·083733	9·829517
	3		54	17·73	−24	57	48·6	0·089982	9·841123
	4		56	36·69		51	50·7	0·095968	9·852393
	5	20	58	54·85		45	33·0	0·101702	9·863337
	6	21	1	11·99		38	58·3	0·107199	9·873968
	7		3	27·93		32	8·9	0·112469	9·884298
	8		5	42·59		25	6·7	0·117525	9·894337
	9		7	55·83		17	53·6	0·122377	9·904096
	10		10	7·55		10	31·5	0·127034	9·913588
	11		12	17·69	−24	3	1·7	0·131504	9·922823
	12		14	26·20	−23	55	25·6	0·135797	9·931812
	13		16	33·03		47	44·4	0·139920	9·940566
	14		18	38·15		39	59·2	0·143880	9·949094
	15		20	41·53		32	10·9	0·147684	9·957404
	16		22	43·16		24	20·4	0·151338	9·965507
	17		24	43·04		16	28·5	0·154848	9·973410
	18		26	41·14		8	36·0	0·158219	9·981121

1862.	R.A. h m s	Decl. ° ′ ″	Log Δ.	Log r.
Mar. 19	21 28 37·48	−23 0 43·6	0·161455	9·988648
20	30 32·05	−22 52 51·8	0·164562	9·995998
21	32 24·86	45 1·3	0·167544	0·003178
22	34 15·90	37 12·6	0·170406	0·010195
23	36 5·19	29 26·2	0·173150	0·017054
24	37 52·73	21 42·6	0·175781	0·023762
25	39 38·52	14 2·2	0·178302	0·030325
26	41 22·58	−22 6 25·2	0·180717	0·036748
27	43 4·91	−21 58 52·0	0·183028	0·043035
28	44 45·51	51 23·2	0·185239	0·049192
29	46 24·39	43 59·0	0·187352	0·055223
30	48 1·57	36 39·7	0·189370	0·061133
31	49 37·06	29 25·6	0·191296	0·066926
April 1	51 10·86	22 16·8	0·193132	0·072605
2	52 42·99	15 13·7	0·194881	0·078176
3	54 13·45	8 16·5	0·196545	0·083641
4	55 42·25	−21 1 25·4	0·198125	0·089003
5	57 9·40	−20 54 40·6	0·199624	0·094266
6	58 34·92	48 2·3	0·201044	0·099434
7	21 59 58·80	41 30·6	0·202386	0·104508
8	22 1 21·07	35 5·6	0·203653	0·109493
9	2 41·73	28 47·6	0·204847	0·114391
10	4 0·79	22 36·6	0·205969	0·119204
11	5 18·25	16 32·8	0·207021	0·123935
12	6 34·12	10 36·4	0·208004	0·128587
13	7 48·42	−20 4 47·6	0·208919	0·133161
14	9 1·14	−19 59 6·4	0·209767	0·137661
15	10 12·30	53 33·0	0·210550	0·142088
16	22 11 21·89	−19 48 7·6	0·211268	0·146445

Elements.

Epoch, 1862, Feb. 6, 20 Berlin.

$L = 158° \; 1' \; 0''$	Mean longitude.	
$M = 0 \; 0 \; 10$	Mean anomaly.	
$\varpi = 158 \; 0 \; 50$	Long. of perih.	Mean Eq. Feb. 6.
$\Omega = 334 \; 30 \; 50$	Long. of node.	
$i = 13 \; 5 \; 0$	Inclination.	
$\phi = 57 \; 57 \; 20$	Angle of excentricity.	
$n = 1074''{\cdot}625$	Mean diurnal motion.	
$\text{Log.}\, a = 0{\cdot}3458331$		

Observations of Comet II., 1861, *at the Sydney Observatory.* By W. Scott, Esq., Astronomer for New South Wales.

I send herewith some observations of a very fine comet discovered on the 13th of May by Mr. Tebbutt, a young Australian farmer and self-taught astronomer. Mr. Tebbutt communicated his discovery to me on the 21st, but I was unable to obtain any observations of any value until the 27th and 30th, when the comet was just visible after sunset to the naked eye. The observations were made with Sir T. Brisbane's old equatoreal with a ring-micrometer.

An equatoreal telescope with 7-inch object-glass by Merz and Son, having arrived, I succeeded in getting it mounted on the 4th of June, and on the morning of the 8th obtained the first observations with it of the comet, which was then plainly visible to the naked eye.

The comet is now sufficiently brilliant to be seen without a telescope 40 minutes before sunrise; its tail extends 18° in a direction 15° W. of South, one narrow stream of light extending twice as far as the rest of the tail. The nucleus is distinct and round, presenting no remarkable features.

Unfortunately, the Time Ball Tower, to which such undue prominence was given in the building of the Observatory, prevents me from observing with the new instrument until a few minutes before the increasing daylight renders the comet invisible; consequently, I have been compelled to make the last two days' observations with the old instrument mounted in a window on the east side of the building.

The possession of a first-class telescope will enable me now to commence a work which I have long contemplated, namely, the reobservation of Sir J. Herschel's double stars.

Greenwich Mean Time.				Star.	R.A. Comet — Star.	(North +) Decl. Comet — Star.
d	h	m	s		m s	′ ″
May 26	20	1	40	B.A.C. 1250	+1 21·5	*
		9	26		20·6	+11 34
		13	54		21·3	*
		18	42		20·5	11 41
		28	12		21·8	11 37
29	20	7	3	B.A.C. 1250	+2 9·3	+21 30
		12	36		10·4	21 43
June 8	6	56	22	Star of 8th magnitude. Approximate R.A. $3^h\ 59^m\ 5^s$ Decl. $-28°\ 43'\ 15''$	+2 28·7	−8 33
	7	0	35		28·9	29
		6	42		28·9	28
		11	19		29·4	24
		18	19		29·1	22

* Too near the diameter of the ring to be depended on for declination.

Greenwich Mean Time.		Star.	R.A. Comet — Star.	(North +) Decl. Comet—Star.
d	h m s		m s	′ ″
June 10	6 46 8	B.A.C. 1273	+3 19·1	−6 25
	51 56		19·2	11
	7 3 59		19·6	5 55
	9 16		20·0	6 6

B.A.C. 1273 has been observed four times with the meridian circle in 1859 and 1860.

Its tabular position requires correction + 0ˢ·3 in R.A.
... ... + 0″·7 in N.P.D.

None of the other stars have been observed here on the meridian.

Greenwich Mean Time.		Star.	R.A. Comet — Star.	(North +) Decl. Comet—Star.
d	h m s		m s	′ ″
June 11	6 3 4	Star of 7th magnitude. Approximate R.A. 4ʰ 1ᵐ 39ˢ Decl. −27° 47′ 23″	+2 29·6	+4 57
	7 29		29·8	5 18
	11 29		30·0	23
	15 31		29·9	22
	19 40		30·3	30
	23 37		30·4	34
	27 32		30·5	46
14	6 4 40	B.A.C. 1355	−7 50·9	+9 18
	15 3		50·1	42
	25 10		48·6	59
15	6 1 2	Lacaille 1431	−7 46·1	+6 33
	10 58		45·8	7 2
	20 7		44·3	7 20
	37 10		43·9	7 24
16	5 55 29	Lacaille 1379	+4 27·3	−0 11
	6 2 8		27·8	+0 11
	8 21		28·3	17
	15 25		29·0	37
	21 39		29·1	48
17	5 35 37	B.A.C. 1334	+0 45·6	+11 35
	38 31		46·3	51
	41 9		46·2	49
	46 43		47·8	12 11
	48 35		47·4	22
	51 24		47·8	26
	53 46		49·7	28
	56 59		48·6	31
	6 1 23		49·0	54
	5 27		47·3	13 3

Greenwich Mean Time.		Star.	R.A. Comet—Star.	(North +) Decl. Comet—Star.
d	h m s		m s	′ ″
June 20	7 47 52	Star of 7th magnitude. Approximate R.A. $4^h 23^m 15^s$ Decl. $-18° 46' 30''$	−0 35·3	+25 22
	52 16		34·0	42
	55 38		33·4	26 7
	58 33		33·7	20
	8 1 46		33·5	36
	5 7		32·8	52
	8 6		32·4	27 5
	11 53		31·7	24

The Longitude of the Sydney Observatory is $10^h\ 5^m\ 0^s$
Assumed Latitude ... ... $-33° 51' 41''$

Observatory, Sydney, June 21st, 1861.

A later communication has been received, as follows:—

The accompanying observations are corrected for refraction and proper motion. There is some reason to believe that the assumed longitude of the observatory is 10^s too large, being deduced from Moon Culminations and the *Nautical Almanac* tables for 1859–60. It may, therefore, be desirable to add 10^s to the Greenwich mean times of observation.

Greenwich M.T.		Star.	Com.—Star. R.A.	Log.Factor for Parallax.	(North +) Com.—Star. Decl.	Log.Factor for Parallax.
d	h m s		s		′ ″	
June 22	8 28 40	Weisse, IV. 655	− 10·6	8·68487	−4 12	9·64134
	31 23		10·5	8·68167	3 52	9·63923
	33 29		10·2	8·67905	3 38	9·63796
	35 49		− 9·7	8·67614	−3 17	9·63634
23	8 5 28	8th mag. Approx. Pos. R.A. $4^h 37^m 40^s$ Decl. $-10° 12'$	− 47·0	8·70648	+5 31	9·68390
	8 31		45·9	8·70368	5 46	9·68278
	11 19		44·8	8·70100	6 12	9·68094
	13 59		44·2	8·69840	6 30	9·67963
	16 29		43·5	8·69585	6 51	9·67842
	18 51		− 42·9	8·69347	+7 16	9·67711
25	7 40 31	Lalande, 9458.	−1 45·1	8·72402	+0 22	9·74049
	45 55		42·9	8·72063	1 42	9·74032
	49 3		41·5	8·71866	2 21	9·74026
	52 15		40·6	8·71649	3 18	9·74018
	57 39		38·2	8·71262	4 19	9·74001
	8 0 55		37·0	8·71015	5 10	9·73997
	4 32		− 35·4	8·70724	+6 5	9·73992

Greenwich M.T.	Star.	Com.—Star. R.A.	Log. Factor for Parallax.	(North +) Com.—Star. Decl.	Log. Factor for Parallax.
d h m s		s		′ ″	
June 26 7 46 24	Lalande, 9757.	− 32·2	8·72784	+4 51	9·75908
49 20		30·7	8·72618	5 47	9·75990
56 37		27·5	8·72170	8 7	9·76187
59 6		25·7	8·72008	8 45	9·76257
8 1 38		24·9	8·71836	+9 30	9·76323

The following orbit, computed by Mr. Hawkins of Goulburn, agrees very closely with the observed positions:—

Perihelion Passage, Greenwich Mean Time, June	d 11·75008
Perihelion Distance	0·822152
Longitude of Node	° ′ ″ 279 1 41
Inclination	85 37 46
Distance of Node from Perihelion	29 38 59
Heliocentric Motion	Direct.

Observatory, Sydney, August 11, 1861.

Observations of Comet II., 1861, *made at the Dudley Observatory, Albany, U.S.A.* By G. W. Hough, Assistant.

(*Communicated by Professor Mitchell through the Astronomer Royal.*)

M.T. Dudley Observatory.		App. R.A.	App. Decl.
1861.	h m s	h m s	° ′ ″
July 3	15 21 8·75	10 10 27·02	+66 33 2·82
5	13 39 8·37	12 0 12·54	65 58 6·92
7	11 22 30·00	13 1 53·67	63 7 51·90
12	11 0 41·50	14 7 46·17	56 58 22·76
18	9 6 23·86	14 35 6·21	52 42 33·05
21	15 33 13·70	14 43 26·60	51 10 38·40
23	11 53 46·64	14 47 9·63	50 27 56·72
25	9 42 52·04	14 50 31·27	49 48 51·23
30	11 9 55·95	14 57 53·45	48 23 20·54
Aug. 3	10 30 17·56	15 2 47·41	+47 29 14·87

July 3. Observed with the Olcott Meridian Circle at the lower Culmination. Fifteen wires observed in R.A. The remaining observations were made with the Equatoreal. The diff. in R.A. between the Comet and Comparison Star was determined by recording their transits (across three wires of the micrometer) in the Chronograph.

	Comp. Stars.	Comp.
July 5.	22785 L. L., 12372 Arg.	3
7.	24511 L. L., 13387 Arg.	3
12.	14403 Arg.	3
18.	14785 Arg.	3
21.	14869 Arg.	3
23.	14884 Arg., 4134 Rümker	3

	Comp. Star.	Comp.
July 25.	14971 Arg., 4878 Rümker	4
30.	4922 and 4930 Rümker	6
Aug. 1.	4961 Rümker	5

The observations are not corrected for parallax.

And with the foregoing observations Prof. Mitchell also communicated—

Approximate Elements of Comet II. 1861.

1861, Washington M.T. June 11·668.

$$\left.\begin{array}{l}\pi = 249^\circ\ 37'\cdot7 \\ \Omega = 278\ 58\cdot1\end{array}\right\}\text{App. Eq., July } 3^{d}\cdot0$$

$$i = 85\ 23\cdot7$$

$$\text{Log } q = 9\cdot916390.$$

Direct.

From observations of July 3, 12, and 25.

Observations of Comet II. 1861, *with the Equatoreal, at the United States Naval Observatory, Washington.* By Mr. James Ferguson, Assistant Astronomer.

(*Communicated by Commander J. M. Gilliss.*)

M.T. Washington.		Comet—Star. Δ R.A.	Comet—Star. Δ Decl.	Comet's Apparent R.A.	Comet's Apparent Decl.
1861	h m s	m s	′ ″	h m s	° ′ ″
July 2	9 55 19·3	+ 0 38·84	+ 5 58·79	8 43 6·97	+63 12 14·65
3	8 46 46·3	+12 12·30	− 4 22·69	9 51 41·15	66 9 52·46
„	9 10 7·3	+ 4 7·69	+11 36·35	9 52 52·55	66 11 36·73
4	8 51 20·5	+ 1 17·95	+16 51·38	10 58 36·26	66 54 20·63
6	9 0 52·5	+ 5 28·25	+19 35·73	12 31 12·57	64 51 7·59
8	8 51 54·0	− 1 8·74	− 6 34·76	13 20 47·48	61 50 8·93
12	10 10 53·1	− 1 40·65	+ 0 5·69	14 7 35·00	56 58 13·53
14	10 23 52·0	+ 5 23·97	−15 15·40	14 19 45·09	55 14 25·87
16	9 10 58·8	− 0 36·04	+21 37·52	14 28 23·77	53 52 7·76
17	8 29 29·1	− 4 30·63	+15 1·99	14 31 53·61	53 16 40·10
20	9 55 15·2	− 4 26·76	−14 35·12	14 40 37·21	51 42 28·91
23	9 1 48·1	− 4 50·84	+18 25·42	14 46 58·13	50 30 18·35
24	8 32 46·4	− 3 3·55	− 2 24·53	14 48 45·39	50 9 28·30
25	8 50 54·5	− 0 51·32	+10 36·52	14 50 29·23	49 49 16·30
27	9 0 37·5	+ 1 8·24	+15 31·25	14 53 38·04	49 12 26·44
30	8 27 55·7	− 1 29·14	+12 59·41	14 57 45·86	48 24 42·34
Aug. 1	8 42 5·6	− 1 4·48	−15 37·36	15 0 19·43	47 56 5·37
4	8 48 54·9	− 2 18·08	− 4 55·72	15 3 52·88	47 17 34·70
6	8 46 10·2	+ 2 5·21	− 6 16·41	15 6 8·52	46 54 17·26
15	8 15 7·3	+ 1 56·99	− 4 52·68	15 15 53·75	+45 26 27·12

1861	No. of Comp.	Comp. Star.	1861	No. of Comp.	Comp. Star.
July 2	10	A.Z.N. 187·74	July 20	5	1668 Cat. Gen.
3	2	2396 Radcliffe.	23	7	†3293 Radcliffe.
„	5	A.Z.N. 176·26.	24	10	„ „
4	12	„ 176·13.	25	11	A.Z.N. 2·22.
6	4	„ 186·96.	27	7	„ 2·23.
8	9	„ 203·66.	30	7	2317 Radcliffe.
12	5	* „ 109·92.	Aug. 1	10	„ „
14	5	„ 5·8.	4	6	‡1697 Cat. Gen.
16	10	4760 Rümker.	6	5	§A.Z.N. 118·8.
17	3	Star 11.	15	7	„ 118·21.

Mean places for 1860·0 of Comparison Stars.

		R.A. h m s	Decl. ° ′ ″	
A.Z.N. 187,74	8·5	8 42 21·24	+63 6 30·15	Arg. Northern Zones.
2396 Radcliffe	6	9 39 22·18	66 14 32·14	Radcliffe Cat.
A.Z.N. 176,26	9	9 48 38·30	66 0 17·90	Arg. Northern Zones.
„ 176,113	7	10 57 12·41	66 37 48·72	„ „
„ 186,96	8	12 25 39·35	64 31 51·80	Argel. N.Z. and Rümker.
„ 203,66	9	13 21 51·68	61 57 2·60	Arg. Northern Zones.
* „ 109,92	9	14 9 11·57	56 58 24·56	„ „
„ 5,8	7	14 14 17·03	55 30 33·18	Argel. N.Z. and Rümker.
4760 Rümker	7	14 28 55·39	53 30 47·85	Rümker's Cat.
Star 11	10	14 36 19·83	53 1 55·85	W. Equat. from A.Z.N. 1,39
1668 Str. Cat. G.	6	14 44 59·58	51 57 21·05	Struve Cat. G. and Rümker.
†3293 Radcliffe	5	14 51 44·56	50 12 10·09	Radcliffe and A.Z.N.
A.Z.N. 2,22	9	14 51 16·09	49 38 57·32	Arg. Northern Zone.
„ 2,23	7.	14 52 25·45	48 57 13·00	„ „
3317 Radcliffe	7	14 59 10·68	48 12 0·57	Radcliffe Cat.
‡1697 Str. Cat. G. pr.	9	15 6 6·72	47 22 48·11	Struve and A.Z.N.
§A.Z.N. 118,8	8	15 3 59·12	47 0 51·96	Arg. Northern Zones.
„ 118,21	7	15 13 52·55	+45 31 38·45	Argel. N.Z. and Rümker.

* The mean of 92 and 94 is used.

† This star is 4937 B.A.C. The mean of 3293 Radcliffe, and A.Z.N. 2,24 is used, without correcting for proper motion.

‡ The determination of 1697 Struve is of the sequent star, which is the same as A.Z.N. 118·9, but in the latter determination the declination is 10 minutes too small. It is also 4981 Rümker, who probably observed the preceding star. I have used a mean of Struve and Argelander for the sequent star, and applied the present observed differences for the place of the preceding star, which was used in the comparison.

§ The mean of 118,8 and 113,90 is used.

Mr. Francis Abbott, in a letter dated Hobart Town, June 22, 1861, addressed to Mr. Carrington, incloses a printed letter, giving an account of the same Comet II., 1861, as seen at Hobart Town, as follows:—

"*To the Editor of the Mercury.*

"Sir,—A notice was given in your issue of the 7th instant of a remarkably fine Comet, first seen at Hobart Town on the morning of the 4th, and at present appearing every clear morning in the south-eastern hemisphere, and in the evening near the south-western horizon. From its slow motion and general appearance it may continue for some time to be an object of interest in the southern sky. The comet's position first noticed was in the constellation *Eridanus*, the nucleus lying a little to south of a small star marked 315 a. lc.; it proceeded a little south of o1 and o2, passing between them and 358, all stars of the 6th magnitude. The tail, which is quite straight and about 10 degrees in length, points in the direction of the star *Achernar*, the nucleus forming nearly a right angle with that star and *Canopus*. The nucleus of the comet, measured with a Cavallo's micrometer in an eye-piece of 50, was 33″ in diameter; the coma or nebulosity surrounding the nucleus, as seen with a comet eye-piece of 27 in a 5-feet telescope, was 30 minutes in diameter. The breadth of nebulosity at the apex of the tail 50 minutes, where it becomes very diffuse.

"The approximate positions of the comet, taken every clear morning to the present date, are as follows:—

1861.	Hobart Town M.T. h m	Comet's App. R.A. h m	Comet's App. Decl. ° ′
June 6	4 30 A.M.	4 2	30 20 S.
7	5 40	4 4	29 40
12	4 50	4 14	27 45
16	4 30	4 22	26 30
17	5 40	4 24	26 30
18	5 15	4 26	25 20
19	5 45	4 30	24 0
20	4 50	4 34	23 30

"The comet is very like to the second comet of 1819, which was discovered by Professor Trallis at Berlin, July 1st, and made its appearance suddenly above the N.W. horizon, in the constellation *Lynx*; it was visible to the naked eye, with a bright tail and nucleus, until October 20th.

"Francis Abbott.

"*Murray Street, June 20th, 1861.*"

Mr. Abbott remarks, however, that the right ascension and declination must only be considered approximate, as a few days before the comet appeared he sent his equatoreal and azimuth instruments to Melbourne.

On the Form of the Shadow of Saturn's Ring. By the Rev. T. W. Webb.

The following extract from the *Commentaries of the Royal Society of Sciences at Göttingen*, for the years 1791 and 1792, as published in this country in the *Memoirs of Science and the Arts*, may possibly be worthy of attention, in connexion with Mr. De La Rue and Mr. Lassell's very interesting observations of the irregular form of the shadow of the ring upon the globe of *Saturn*. It occurs in a description of the 13-feet reflector, by Schräder, of which Schröter made such extensive use, and which seems to have been an excellent instrument:—

"On the 26th of December, 1792, the writer (Schröter) observed *Saturn* with power about 300, and saw his belts, the southern broad, like a cloud, the nearest northern much more lucid than the remaining part of the surface, and the shadows which the body cast upon the ring and the ring upon the body. The boundaries of these shadows were jagged."

The irregularity of the shadow, as projected upon the ring, may possibly have been the deviation, so often remarked, where it crosses the principal division. The indentations of the shadow upon the globe may, perhaps, be thought analogous to those recently noticed; but in the case of Schröter's observation, though I have no means at hand of ascertaining the form of the ring in 1792, it is evident that it must have been much more open than at present, as otherwise the outline of the shadow projected upon it could not have been discernible.

Hardwick Parsonage, July 27, 1861.

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield, Sussex. By Capt. W. Noble.

Friday, June 14, 1861.

36 Sextantis.

The star disappeared instantaneously
at $14^h\ 18^m\ 45^s{\cdot}8$ L.S.T. = $8^h\ 46^m\ 15^s{\cdot}98$ L.M.T.

A dense haze of cirri prevented the observation of the reappearance. There was a great deal of atmospheric disturbance.

Tuesday, June 25.

18 Aquarii.

A thick haze surrounding the Moon deprived me of any chance of seeing the disappearance.

The star reappeared instantaneously
at $18^h\ 30^m\ 27^s{\cdot}3$ L.S.T. = $12^h\ 14^m\ 1^s{\cdot}2$ L.M.T.

π Capricorni.

	h m s		h m s	
The star disappeared instantaneously at	19 39 6·2	L.S.T. =	8 4 0·2	L.M.T.
and reappeared at	20 49 1·7	L.S.T. =	9 13 59·5	L.M.T.

Saturday, September 14.

ϱ Capricorni.

The star disappeared instantaneously
at $20^h\ 53^m\ 12^s{\cdot}8$ L.S.T. = $9^h\ 17^m\ 54^s{\cdot}6$ L.M.T.

The reappearance was not observed. The atmospheric tremor was great. In all these observations my 4·2 inch equatoreal was employed, in each case with a power of 115 adjusted on the respective stars.

Captain Noble, in the letter which accompanied the foregoing observations, mentions as a curious fact that on Sunday evening, the 16th of June, while experimenting with the Hodgson eye-piece, upon lunar detail, he was surprised and amused to find that with powers of 160 and upwards the effect presented was a pseudoscopic one. The appearances of the Apennines as a deep and irregular depression in the Moon's surface, and that of the craters as large blisters, was, so to speak, absurd. Steady gazing caused this illusion to disappear, only to reappear again however after a short interval.

Occultation of Stars by the Moon, observed at the Dudley Observatory, Albany, U.S.A. By G. W. Hough, Assistant.

(*Communicated by Professor Mitchell through the Astronomer Royal.*)

			h m s	
ϱ Capricorni,	Immersion,	July 21,	23 18 28·1	Sid. Time.
16 Piscium,	Immersion,	July 25,	20 11 2·2	„

ϱ Capricorni, probably $0^s{\cdot}2$ slow.
16 Piscium: star seemed to hang on the edge of the Moon about $0^s{\cdot}5$ before it disappeared.

Observations of Leto and Virginia, with the Equatoreal, at the United States Naval Observatory, Washington. **By Mr. James Ferguson, Assistant Astronomer.**

(*Communicated by Commander J. M. Gilliss.*)

Leto (68).

M.T. Washington.		(68) — Star. R.A.	(68) — Star. Decl.	(68), Apparent R.A.	(68), Apparent Decl.
1861	h m s	m s	′ ″	h m s	° ′ ″
June 13	9 39 4·7	−0 15·87	− 4 56·57	13 42 13·97	−10 24 12·11
14	8 58 28·3	−0 24·47	− 6 13·71	13 42 5·36	10 25 29·21
18	8 54 48·8	−0 45·47	+12 33·43	13 41 44·00	10 31 48·85

	No. of Comp.	Comp. Star.
1861, June 13	3	Weisse, XIII. 725
14	4	,,
18	3	,,

Mean place for 1860·0 of Weisse XIII. 725.

Mag.	R.A.	Decl.
9·5	$13^h\ 42^m\ 23^s{\cdot}48$	$-10^\circ\ 18'\ 38''{\cdot}52$

Virginia ○.

M.T. Washington.		(50) — Star. R.A.	(50) — Star. Decl.	(50), Apparent R.A.	(50), Apparent Decl.
1861	h m s	m s	′ ″	h m s	° ′ ″
July 25	10 9 9·6	+1 0·79	−17 22·67	20 7 48·90	−16 2 27·49
Aug. 1	9 48 58·8	+3 51·51	+15 45·21	20 1 23·29	16 30 1·33
2	9 24 19·4	+2 58·77	+11 48·75	20 0 30·46	16 33 57·93
3	10 3 26·5	+2 3·88	+ 7 40·06	19 59 35·62	16 38 6·78
4	9 42 34·0	+1 11·95	+ 3 40·15	19 58 43·70	16 42 6·86
6	9 37 31·2	−0 30·58	− 4 20·60	19 57 1·17	16 50 7·95

	No. of Comp.	Comp. Star.
1861, July 25	8	A.C. 20337
Aug. 1	10	,, 20217
2	14	,, ,,
3	11	,, ,,
4	12	,, ,,
6	11	,, ,,

Mean places for 1860·0 of Comparison Stars.

	Mag.	R.A.	Decl.	Authority.
		h m s	° ′ ″	
A.C. 20337	9	20 6 40·13	−15 45 19·22	Argelander's Catalogue Southern Zones.
,, 20217	7·8	19 57 23·70	16 45 58·10	

Mr. Ferguson, the discoverer of the planet (60) hitherto called *Titania*, has written to Mr. Hind, stating that this name was proposed without remarking its previous appropriation by Sir John Herschel for one of the satellites of *Uranus*, and intimating his intention to change it forthwith for *Echo*. This name will appear in the *Nautical Almanac* for 1865.

Discovery of a New Minor Planet, Niobe (71).

The planet was seen by Dr. Luther, as a star of the 11th mag., about 11 in the evening of the 13th August, R.A. 334° 52′, Decl. 0° 7′. On the following evening it was observed as follows:—

	Bilk M.T.	R.A.	Decl.	
1861, Aug. 14	$14^d\ 13^h\ 12^m\ 38^s.4$	334° 34′ 58″.3	−0° 4′ 41″.5	10 Comp. with ✱ *a*.

the daily motion being, therefore,

−16′	+2′

The comparison-star *a* (7, 8) was, according to a new determination by Prof. Argelander, at Bonn, assumed as follows:—

	Apparent R.A.	Apparent Decl.	Mean Position. 1861, 0. R.A.	Mean Position. 1861, 0. Decl.
1861, Aug. 14	334° 6′ 17″.2	−0° 5′ 10″.4	334° 5′ 13″.4	−0° 5′ 33″.5;

and hence the position of B. Z. 34, required the correction,

R.A.	Decl.
−4″.6 (in arc)	−0″.5

The following observations were taken at Bonn by Prof. Wolf:—

	Bonn M.T.	R.A.	Decl.
	h m s	h m s	° ′
1861, Aug. 15	11 51 22.7	22 17 21.07	−0 2.5
	12 37 2.9	22 17 18.49	−0 2 37″.4

Apparent Position of Star *a*.

Aug. 15	$22^h\ 16^m\ 25^s.16$	−0° 5′ 10″.25

The planet was also observed by Prof. Schönfeld, at Mannheim, as follows:—

	Mannheim M.T.	R.A.	Decl.
1861, Aug. 17	$10^h\ 50^m\ 59^s$	$22^h\ 15^m\ 15^s.52$	+0° 1′ 4″.0

The foregoing account is calculated from the *Astron. Nach.*, No. 1323. Several later observations are published in subsequent Numbers.

Re-Discovery of Pseudo-Daphne (56).

M. Goldschmidt announces (*Astron. Nach.*, No. 1325) that, after a search of thirteen months, he has succeeded, August 27, in again finding this planet. This result is owing to the ephemeris of Dr. Luther and the Star-map, hora xx., of Dr. Hencke. The planet was of the 10-11 magnitude, and its position for August 28 was

	Paris M.T. (?)	R.A.	Decl.
Aug. 28	$10^h\ 17^m$	$20^h\ 25^m\ 56^s$	$-6^\circ\ 48'{\cdot}5$

obtained by comparison with the star Lalande 39626 (8-9 mag).

Dr. Luther gives, in the same number, a new set of approximate (ganz flüchtig entworfene) elements, computed to connect the observations of 1857 and 1861, and to show that the planet is distinct from *Daphne*.

Pseudo-Daphne (56), *Elements III.*

Epoch 1857, Sept. $13^h{\cdot}0$ Berlin.

$$\begin{array}{lcl} M & = & 36^\circ\ 9'{\cdot}5 \\ \varpi & = & 294\ 40{\cdot}6 \\ \Omega & = & 194\ 39{\cdot}5 \\ \iota & = & 8\ 3{\cdot}5 \\ \varphi & = & 13\ 7{\cdot}6 \\ \mu & = & 846''{\cdot}72 \end{array}\quad \left.\begin{array}{l}\varpi\\ \Omega\\ \iota\end{array}\right\}\ \text{Mean Equinox, 1861, o.}$$

The Editor has received a communication from the Astronomer Royal as follows:—

"In a paper of official character, written by Lieutenant-General Bäyer, Director of the Prussian Geodetic Survey, and circulated by the Prussian Government among the principal Governments of Europe, the following passage occurs:—

"'Bessel hatt in Jahre 1841 aus 10 Breitengrad-Messungen die Abplattung $\frac{1}{299{\cdot}15}$, den Aequatorial-radius = 372077 Toisen bestimmt, Airy fand 8 Jahre später, aus 14 Breiten- und 4 Längen-grad Messungen, die Abplattung = $\frac{1}{299{\cdot}33}$ und den Aequatorial-radius = 3272120 Toisen.'

"That is to say, Bessel's investigations on the Figure of the Earth were made in 1841, and mine 8 years later, or in 1849.

"My investigations were made long before Bessel's. They are contained in an elaborate article on the 'Figure of the

Earth,' in the *Encyclopædia Metropolitana*. In the printed book, the paper is dated at the end 'August 17, 1830.'

"I do not indicate this error in any spirit of complaint against General Bäyer, whose honourable character is perfectly appreciated in this country. But it is an instance proving that the progress of science in Britain is little known on the Continent; and that a historian of science, in order to avoid error, must carefully examine the literature of the country in which each scientific author has lived and has written."

Mr. Andrew Lang, who (as he mentions in his letter) has been a Fellow of the Society since 1821, and is 82 years of age, has sent an account of the Solar Spots observed by him in the Island of St. Croix, in the West Indies, during the year 1860. The observations were always made in the morning, from 7 to 8 o'clock, with an inverting eyepiece, magnifying 40 times, by Gilbert, applied to a telescope 44 inches focal length and 3¼ inches clear aperture, by Banks. Mr. Lang writes that he has in vain looked for *Vulcan*.

In the *Comptes Rendus*, 3 June, 1861, M. Le Verrier announces the completion of his researches on the motion of the planet *Mars*, and he considers the consequences, in regard to the physical constitution of the Solar System, which are to be derived therefrom in connexion with his former researches on the motions of *Mercury*, *Venus*, and the Earth. The theories of *Venus* and *Mars* agree in showing, that in order to obtain from theory the actual motions of the perihelia of these planets it is necessary to increase by about one-tenth part the mass of the Earth; but the actual motion of the perihelion of *Mercury* cannot be accounted for by means of this change; and as the received mass of *Venus* could not be altered, M. Le Verrier was thus led to conclude the existence of a ring of intra-mercurial masses. A group of asteroids exists as we know between *Jupiter* and *Mars*, and there is reason to believe that there are circulating round the Sun, in planetary space, a large number of very small bodies; as regards the region in the neighbourhood of the Earth's orbit this is certain. Thus, without the above-mentioned alteration in the mass of the Earth, M. Le Verrier obtains with respect to the constitution of the inferior part of our planetary system as deduced from the discussion of the observations, the following conclusions:—

1°. Besides the planets *Mercury*, *Venus*, the Earth, and

Mars, there exists between the Sun and *Mercury* a ring of asteroids, the aggregate of which constitutes a mass comparable to that of *Mercury*.

2°. At the distance of the Earth from the Sun there is a second ring of asteroids, the mass of which is at most equal to a tenth part of the mass of the Earth.

3°. The total mass of the asteroids between *Mars* and *Jupiter* is at most equal to one-third of the mass of the Earth.

4°. The masses of the last two groups are complementary to each other; ten times the mass of the group situate at the distance of the Earth, plus three times the mass of the group situate between *Mars* and *Jupiter*, gives a sum equal to the mass of the Earth.

This last conclusion depends on the measure of the distance of the Earth from the Sun by the observation of the transits of *Venus*, which astronomers agree in considering as very precise.

INSTRUMENTS AND BOOKS FOR SALE.

The family of the late E. J. Burrow, D.D., Archdeacon of Gibraltar, are desirous of disposing by sale of his astronomical instruments and books, namely:—

1. A best constructed $3\frac{1}{4}$-feet achromatic telescope, with $3\frac{1}{4}$-inches object-glass, achromatic finder, sliding steadies, 6 eye-pieces, powers from 40 up to 200, a ring, and a wire micrometer with accommodation metal (adapted to all the eye-pieces) and 4 eye-pieces in white metal, powers from 70 to 180. The tube, in brass, is fitted to a strongly mounted and newly constructed $8\frac{1}{2}$-inch equatoreal, with 3 spirit-levels, strong upright supports, metal axis, graduated declination arc, with clamps, &c., and azimuth and hour-circle plates, and 2 sets of verniers reading off to 12 seconds of time and one minute of space.

The instrument was made by Jones of Holborn, in August 1854, without regard to cost, and is in a high state of preservation. It is now placed for inspection under the care of Mr. J. Williams, the Assistant Secretary, at Somerset House, who is authorized to exhibit the bills of sale, and to treat with any party wishing to become a purchaser.

2. A journeyman clock, striking minutes and half-minutes. Also,

3. A set of "Pearson's Astronomy," 2 vols., and a vol. of Plates, large 4to. boards, and

4. Baily's Catalogue of Stars of the British Association.

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